POWER

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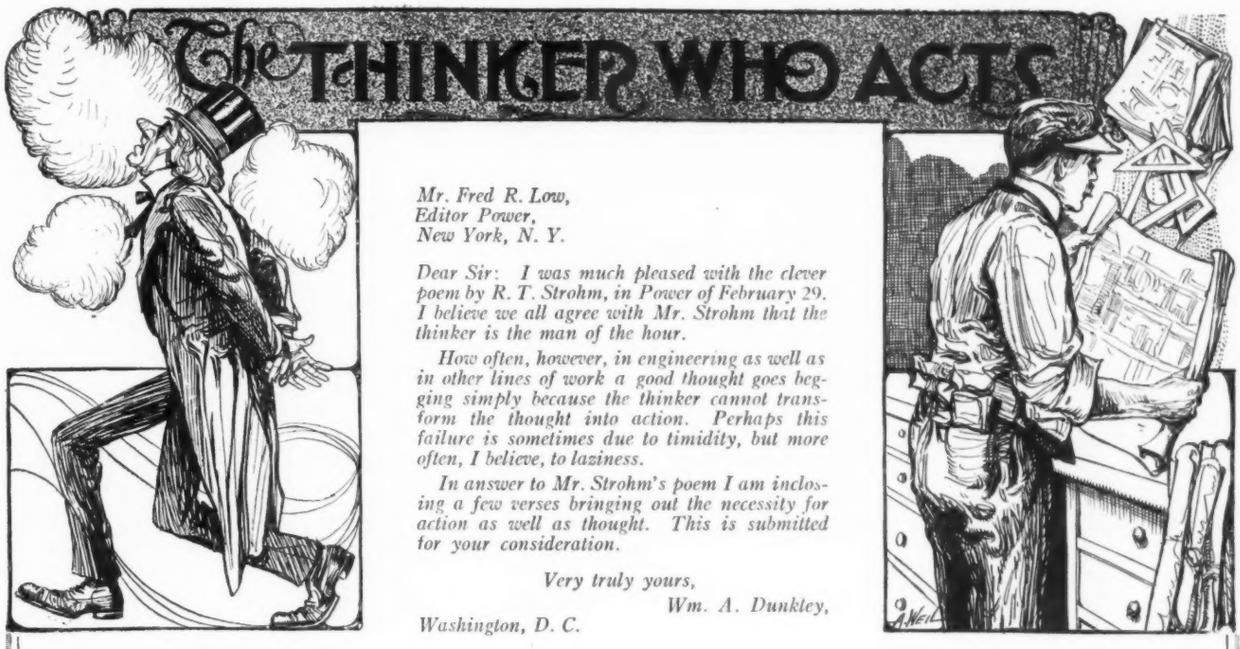


Mr. Fred R. Low,
Editor Power,
New York, N. Y.

Dear Sir: I was much pleased with the clever poem by R. T. Strohm, in Power of February 29. I believe we all agree with Mr. Strohm that the thinker is the man of the hour.

How often, however, in engineering as well as in other lines of work a good thought goes begging simply because the thinker cannot transform the thought into action. Perhaps this failure is sometimes due to timidity, but more often, I believe, to laziness.

In answer to Mr. Strohm's poem I am inclosing a few verses bringing out the necessity for action as well as thought. This is submitted for your consideration.

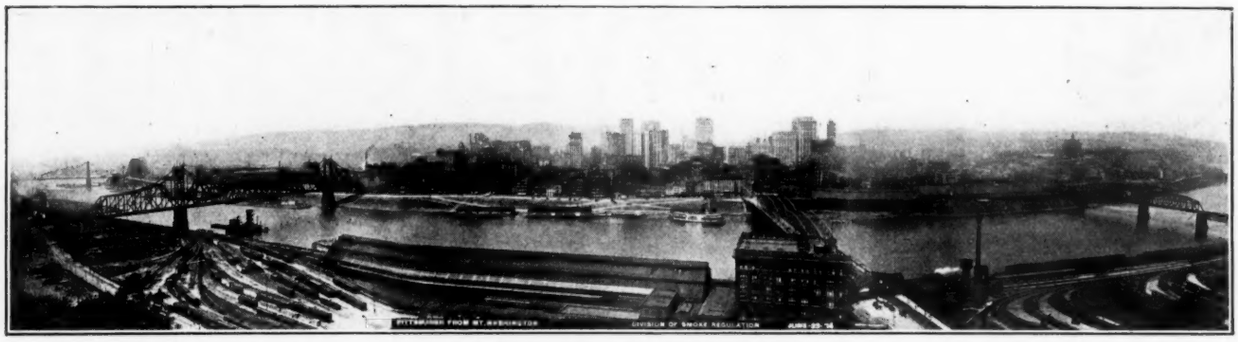
Very truly yours,
Wm. A. Dunkley,
Washington, D. C.

THE world's full of schemers and ossified dreamers,
Who think till they're dried up and fit for the tomb;
But thinkers with hustle, pep, ginger and bustle
Are those who climb up to the top, where there's room.
And so I say plainly and very urbanely
(I'm sure I can prove it an absolute fact),
The only sure winners among us poor sinners
Are those who not only can think but can act.

When Watt saw the kettle bob up in fine fettle,
Its cover alive with the power of steam,
He did not just ponder and aimlessly wonder,
Nor waste all his time in a long idle dream.
No, sir: He got started, in no wise half-hearted,
And worked till he reached the result that he sought.
We scarcely need mention that his great invention
Came only through action, well-coupled with thought.

Columbus, another bright son of a mother,
Was thought by some people a daffy old nut
Because of his notion of lands 'cross the ocean
Against the belief of those stuck in a rut.
But not to be daunted, he got what he wanted,
For Queen Isabella helped out with her "jools;"
And thus he was able to quite turn the table
By putting the laugh on those skeptical fools.

There's many a human with brain and acumen
Could make a real mark in the world if he'd try,
But so lackadaisy or so dog-goned lazy
He'd rather sit down in a corner and sigh.
If you'd do a kindness to one who, in blindness,
Proclaims that the thinker alone should be backed,
Just step in behind him and straightway remind him
It's needful not only to think but to act.



PITTSBURGH AS IT IS NOW ON A WORKING DAY. GOOD ENGINEERING HAS DONE THIS

Passing of the Smoke Nuisance in Pittsburgh

No other city has been confronted with a smoke problem of such magnitude as that of Pittsburgh, or has encountered similar difficulties in solving it. The three rivers, the deep valleys, the frequency of high humidity and the low wind velocity with resultant fogs are some of the conditions to be reckoned with.

The Mellon Institute of Industrial Research has estimated that the smoke nuisance in Pittsburgh costs $10,000,000 a year. But this loss is decreasing as evidenced by the "light smoke" and "dense smoke" records of the local office of the Weather Bureau. There were 55 days of dense smoke in 1913, 32 in 1914 and the comparatively small number of 26 in 1915.

The photographs indicate the progress that has been made. And no court action has been taken against offenders. When they go to court depends chiefly upon themselves. Good combustion engineering coupled with the coöperation of fuel users and favorable public sentiment is responsible. The steam jet is used liberally, and many furnaces have been improved. The railroads have assisted wonderfully in reducing smoke. The engineers of the Pennsylvania Railroad at Pittsburgh start new fires in locomotives without making objectionable smoke. This is accomplished by putting a thin layer of low-volatile coal on the grate and then a layer of oil-soaked shavings on top. The coal fire then burns from the top, the smoke-producing volatile passing through a very hot zone; the steam jet assists.

In many plants openings in the roofs of the boiler houses have been made so the firemen may easily observe the stack; other plants use reflecting mirrors. Fuel users have spent considerable to reduce the smoke, but most of them claim that the saving in fuel has repaid them. The consumption of low-volatile coal is urged, and in small hand-fired plants this fuel greatly diminishes the smoke. Stokers are recommended for plants where the fuel consumption will make the investment worth while.

The great steel mills, heretofore producers of the most objectionable smoke, have been most liberal in their co-operation with the Bureau of Smoke Regulation. The Chamber of Commerce, department stores, also many citizens have aided in the campaign of the Bureau.

PITTSBURGH AS IT WAS; THE BUILDINGS ACROSS THE RIVER VEILED IN SMOKE

Standard Oil Boiler Plants at Whiting

By Thomas Wilson

SYNOPSIS—Two uptodate boiler plants having a combined rated capacity of 9,000 b.hp. Complete coal-handling equipment, special feed-water heaters and unique regulator to control the supply for the boilers. Breeching utilized to heat air entering boiler room.

Whiting, Ind., is known all over the country as an oil center. It is here that the Standard Oil Co. of Indiana has one of the largest and most complete refineries in the world. Per day 40,000 barrels of crude oil are refined into a complete line of products ranging from gasoline to the final residuum, petroleum coke. The site extends along the shore of Lake Michigan for a distance of 1¼ mi. It is one-half mile wide and covers an area of about 450 acres.

In the manufacturing processes a great deal of steam is required, and besides the works has a power plant to supply current for lighting and various motors, in addition to a pumping station serving the refinery and the City of Whiting. The power plant contains three Corliss-engine units directly connected to 500-kw. two-phase 480-volt generators. Owing to increasing power demands a 1,000-kw. turbo-generator has just been installed. The pumping station contains two 11,000,000-gal. and two 10,000,000-gal. centrifugal pumps, each directly connected to a 200-hp. motor. There is also a cross-compound condensing steam-driven pumping unit having a capacity of 20,000,000 gal. per 24 hr. These pumps deliver water throughout the yards at a pressure of about 25 lb. at the station. In addition a number of steam fire pumps are located at various points on the premises to furnish high-pressure service through a separate system of mains. For city service there are two duplex steam pumps and one fire pump.

Exhaust Steam Supply

The exhaust from all steam-using equipment is used in the manufacturing processes at a back pressure ranging from 1 to 8 lb. The supply is far from adequate, so that it is supplemented by all the steam that can be generated in the existing boiler plants. Transmission losses that would result with the entire boiler capacity centralized have determined the present policy of installing a number of plants located at the various centers of demand. These plants, however, are interconnected, so that if for any reason one plant is down, any of the others may come to its support. At the present writing there are five plants. Three, containing return-tubular boilers, have been in service for a number of years. In July, 1914, a 3,000-hp. water-tube boiler plant was put into commission, and a plant containing twelve 500-hp. boilers, or a total of 6,000-hp., has just been completed.

From these five boiler plants live steam at 80-lb. pressure is conducted above ground, through pipe lines covered with felt and asbestos and supported on stanchions, to the various points of usage such as the power plant, pumping station, the various oil pumps and engines distributed around the works and the departments requiring live steam in addition to the exhaust steam available. For the service last named the live steam at the delivery end of the line is reduced to the back pressure in the exhaust mains.

The entire country around the works is only one or two feet above the level of Lake Michigan, and as the plant is near the lake shore, all pits and excavations must be provided with steel tanks or else pumped continuously to prevent flooding. The basement of the new boiler plant was accordingly made at the yard level and the boiler floor elevated. Like all of the other new structures the building is of reinforced-concrete. The floor slabs and piers were made amply strong to carry the weight of the boilers, settings, stokers and other heavy apparatus.

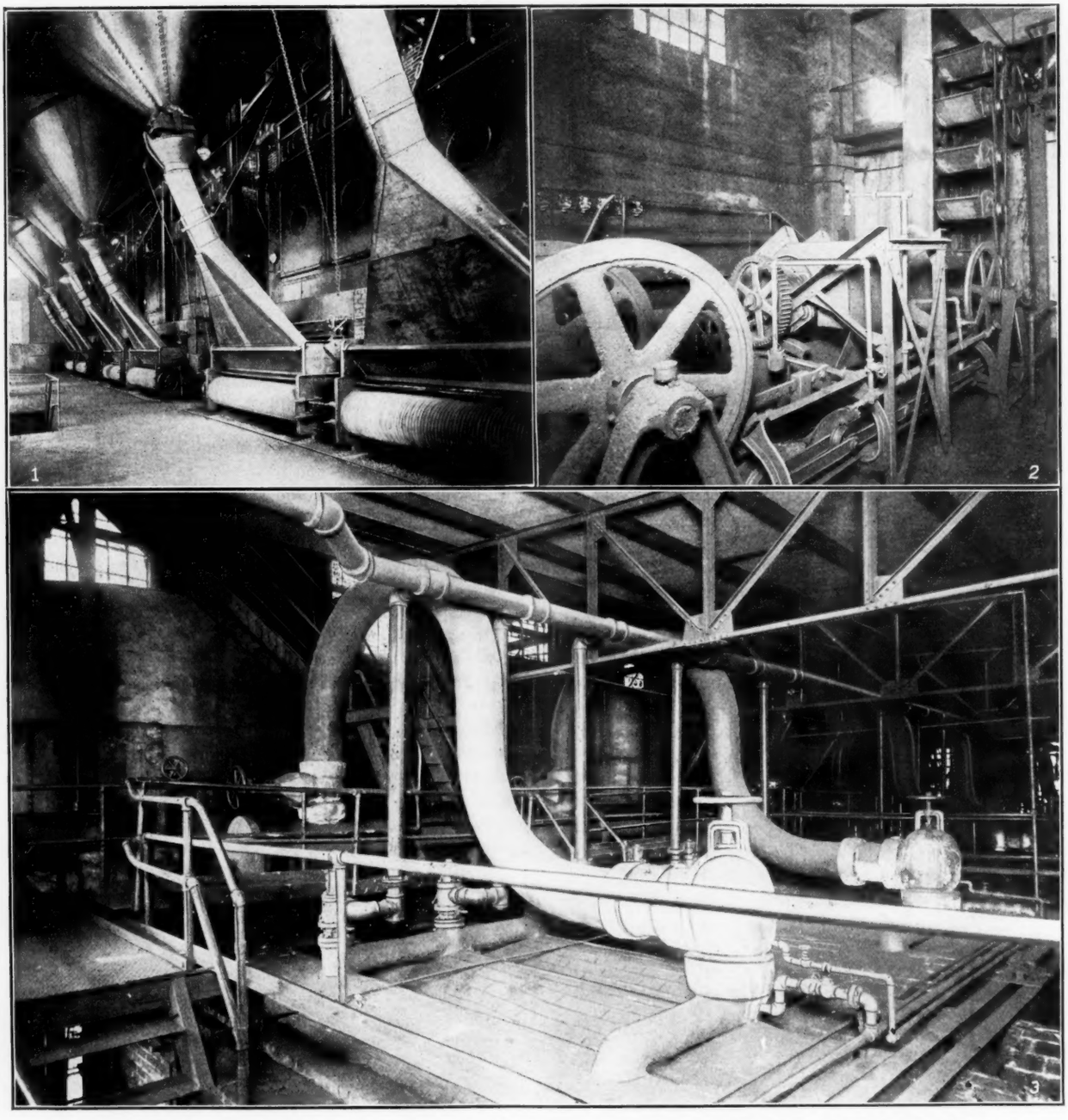
The 3,000-Hp. Boiler Plant

The equipment shown in Figs. 1, 2 and 3, consists of six horizontal water-tube boilers of the three-pass type arranged in batteries of two. Each boiler is rated at 500 hp., has 5,080 sq.ft. of heating surface and is equipped with a chain-grate stoker having an area of 110 sq.ft., the latter bearing a ratio to the heating surface of 1 to 46. The furnace, which extends 4 ft. from the boiler front, has a flat arch. After making three passes over the heating surface, the gases flow to the rear and down around the headers to the outlet, the bottom of which is 9 ft. above the floor line. Natural draft is supplied by a concrete stack 12 ft. diameter at the top and 250 ft. high above grade, or 225 ft. above the grate. The stack has tapering walls and is lined for a distance of 80 ft. from the base.

As the boilers are set close to the wall, the breeching has been located outside of the building. It is of tapering section increasing from both ends toward the center, where the stack is located. It is 7 ft. wide and at the opening into the stack 20 ft. high. Its area is 135 sq.ft., which is practically 20 per cent. greater than the area of the stack. From the data previously given, the following relations may be established: Per 1,000 sq.ft. of boiler-heating surface the plant contains 21.6 sq.ft. of connected grate area, 4.43 sq.ft. of breeching area and 3.71 sq.ft. of stack area.

Breeching Heats Air to Boiler Room

An unusual feature is a galvanized iron jacket over the breeching, spaced sufficiently distant from the walls to allow a current of heated air to flow into the boiler room. Dampers are provided on either side at the bottom of the breeching and at the opening through the boiler-room wall, so that the supply of air may be shut off or controlled at will. The freezing of a gage-glass on a boiler that was down and of the drips in cold weather suggested the idea. Utilizing the waste heat of the gases in the breeching in this way raises the temperature of the outside air 80 to 90 deg. without seriously affecting the draft. Even in the coldest weather the boiler room is now quite comfortable, and there has been no trouble from freezing. During the summer the dampers are



FIGS. 1 TO 3. VIEWS IN AND ABOUT THE BOILER PLANT OF THE STANDARD OIL CO.'S PLANTS

Fig. 1—Boiler room in 3,000-hp. plant. Fig. 2—Apron conveyor from track hopper delivering into bucket conveyor. Fig. 3—Piping above boilers; cylindrical bunkers in background

closed and the air for combustion is drawn through natural openings such as windows or doors.

In the official acceptance test on one of these boilers, an evaporation from and at 212 deg. of 9.455 lb. of water per pound of coal as fired was obtained. The boiler was operated at 186 per cent. of rating and showed an over-all efficiency of 76.09 per cent. O'Gara screenings containing 12,055 B.t.u. per lb. of coal as fired were burned. The average steam pressure was 82.6 lb. gage, the uptake temperature 640 deg., the draft in the furnace 0.23 in., and the drop through the boiler setting 0.27 in. The fuel bed was 6 in. thick.

As shown in Fig. 4, coal for the boilers is dumped from railway cars into a track hopper, from which it is discharged directly upon an 18-in. apron conveyor delivering into a 24x24-in. continuous bucket conveyor running up over the bunkers. The latter are steel with cylindrical tops and conical bottoms, each holding 65 tons. There is one bunker for each boiler, and through duplex gates at the bottom the coal is chuted to the stoker hoppers.

Fine coal dropping through the grates collects in a concrete pan under the stokers. It is scraped into a spout leading to the bottom run of the bucket conveyor and returned to the bunkers. The ashes, dropping into hoppers at the end of the stokers, are discharged directly into railway cars and used on the premises for filling.

The capacity of the coal-handling equipment is 60 tons per hr. A 30-hp. motor drives the bucket conveyor, and the apron conveyor is driven by a motor rated at

15 hp. The stokers are driven by a 10-hp. back-geared motor, and a small vertical engine of the same capacity is provided as a reserve.

Cooling water from the oil condensers is utilized as boiler feed. At a temperature of 100 to 150 deg., depending upon the season, it is pumped into two large storage tanks, each 50 ft. diameter by 30 ft. high. From storage it is pumped into a special home-made feed-water heater of the open type, which is filled with granite boulders. The water is sprayed from the top, and exhaust steam comes up from the bottom. Thorough contact between the steam and the water is thus afforded, and a temperature sometimes as high as 220 deg. in the heater is reached. From this heater, or tower, as it is called, the water flows by gravity into a storage tank below, which is 7 ft. in diameter and 20 ft. long. The elevation of the tank is such as to provide a head of 5 ft. on the suction of the boiler-feed pumps. Usually this insures satisfactory operation of the pumps, but at times it is necessary to use a little cold water to prevent the valves from slamming.

As the various pumps are controlled by hand, an ingenious water-level indicator has been devised. It is a float and lamp arrangement. The former is in the storage tank under the heater and is connected with a rod with spiral threads running through a disk above the tank. At the upper end of the rod is a contact arm, which revolves as the float rises or falls, and makes contacts with the terminals of various lights mounted on an indicating board in the boiler room. At the bottom of the board is a red light indicating low water and next in order are green, white, green and red lights. Ordinarily two lights burn at a time except when the water is at the upper or lower limit, when only a red light shows. In either case it is an indication that the pumps handling the water need attention. A gage-glass on the storage tank also shows the water level.

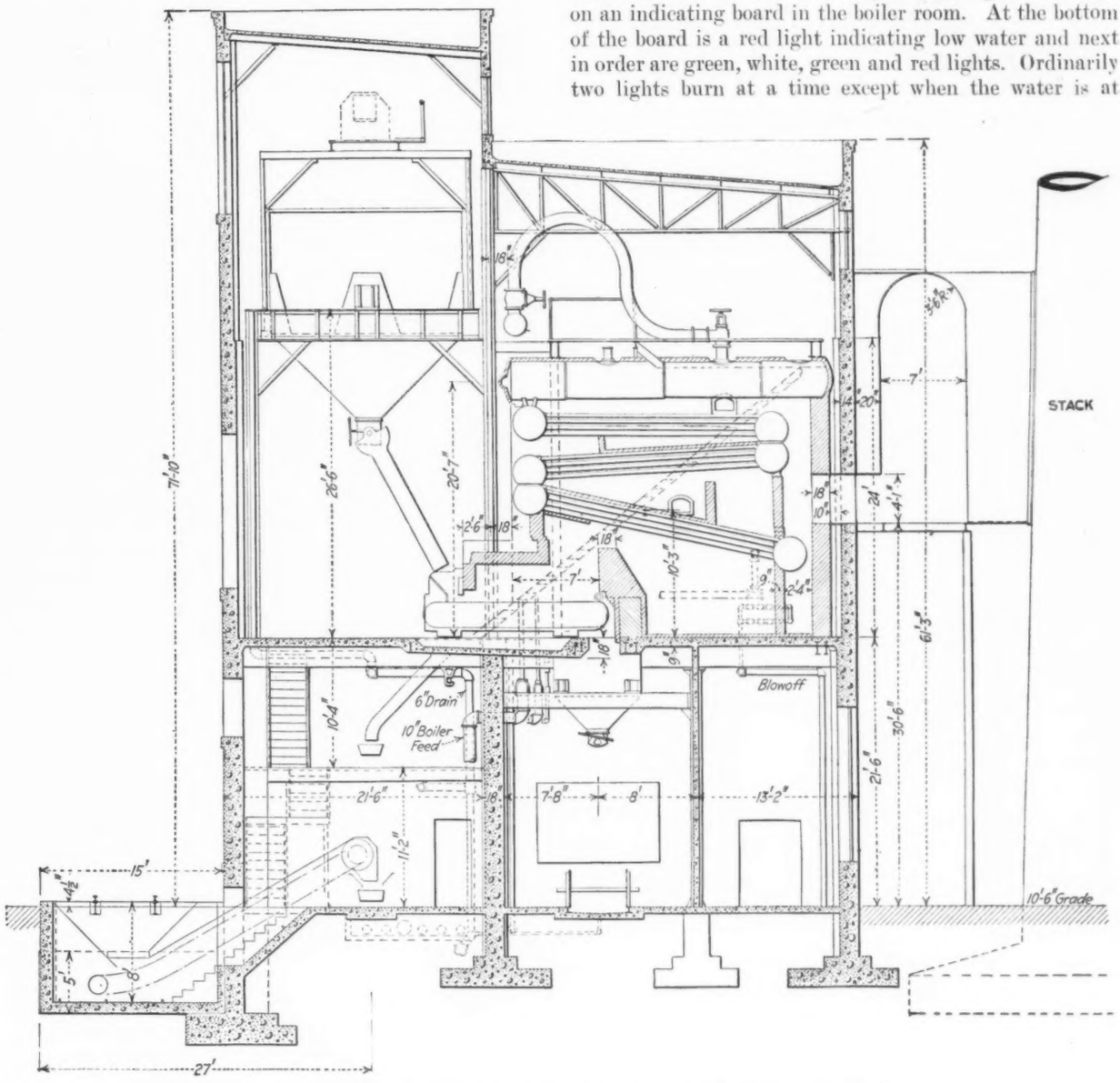


FIG. 4. SECTIONAL VIEW THROUGH ONE OF THE BOILER PLANTS

The new boiler house has double the capacity of the plant installed in 1914. It has the same type and size of boilers and, as shown in Fig. 6, they are arranged in two rows facing each other, with six boilers on either side of the boiler room set singly. As in the other plant, the boilers operate at 80 lb. pressure. The bottom of

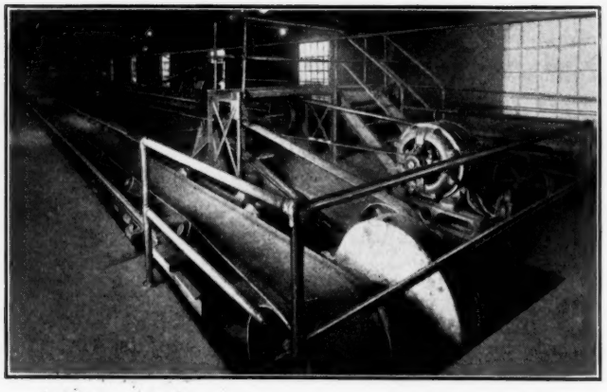


FIG. 5. BELT CONVEYORS OVER STORAGE BUNKERS

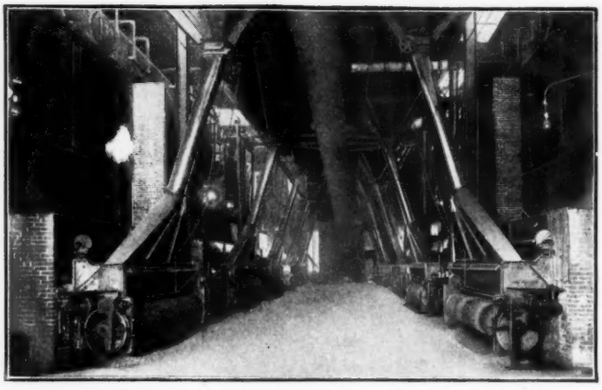


FIG. 6. FIRING AISLE IN 6,000-HP. BOILER PLANT

the front header is 12 ft. off the floor, so that large combustion space is available, and the grate area has been increased to 132 sq.ft., giving a ratio of grate area to boiler-heating surface of 1 to 39. Under these favorable conditions a boiler is guaranteed to develop 300 per cent. of rating, or 1,500 b.hp.

To conform with the duplicate arrangement of the plant, there is a breeching on either side of the boiler house, each leading into a reinforced-concrete stack 250 ft. high, 14 ft. diameter at the top and 21 ft. outside diameter at the base. The stack foundations are 39 ft. square and extend 8 ft. 6 in. below the ground level. In the new plant the breeching is also utilized to heat the air entering the boiler room. In this case, however, air is admitted only through the outer opening between the jacket and the wall of the breeching, so that it must pass all the way around the breeching and enter the boiler room at the bottom of the inclosure, as indicated in Fig. 7. The breeching is 9 ft. wide by 21 ft. high at the entrance into the stack and has an area of 180 sq.ft., which is 17 per cent. greater than that of the stack, the latter having an area of 154 sq.ft. Per 1,000 sq.ft. of boiler-heating surface these areas reduce to 5.9 sq.ft. for the breeching and 5.05 sq.ft. for the stack. On the same basis there is 26 sq.ft. of connected grate area.

Provision has been made for burning oil if the coal supply should fail. Two supply tanks 16 ft. diameter by 15 ft. high have been provided outside of the boiler room and in addition pumps and piping from the tanks to the furnaces. To change the fuel it would be necessary only to brick up the furnaces and install burners.

As shown in Fig. 7 the coal-handling equipment has been installed in duplicate and is so arranged that only one unit need be operated at a time. It is unusually complete and reduces the labor for handling coal and ashes in this plant to a minimum. The layout has a number of features differing from the average installation.

Run-of-mine coal is received in bottom-dump railway cars on a siding running parallel with and alongside of the boiler house. This track has ample storage capacity for a day's supply of coal in the cars and has a slight grade so that the cars can drift over the dump hopper as required. A double-track hopper is provided long enough to permit both ends of a hopper-bottom car to be dumped into it at the same time. It will take the full length of a side-dump car, so that only one spotting is necessary. This feature saves time and is important,

PRINCIPAL EQUIPMENT OF STANDARD OIL BOILER PLANTS AT WHITING, IND.

No.	Equipment	Kind	Size	Use	Operating Conditions	Maker
6	Boilers	Water-tube	500-hp.	Generate steam	Pressure, 80 lb.; stokers, natural-draft	Henry Vogt Machine Co.
6	Stokers	Chain-grate	110-sq.ft.	Serve boilers	Driven by 10-hp. Westinghouse motor or Wachs engine	Illinois Stoker Co.
1	Stack	Reinforced-Concrete	12x250-ft.	Serve boilers		General Concrete Construction Co.
2	Pumps	Duplex	12x10x18-in.	Water from storage to heaters		National Transit Co.
2	Pumps	Duplex	18x14x24-in.	Boiler-feed pumps		National Transit Co.
1	Conveyor	Apron	18-in.	Coal from track hopper to bucket conveyor	Driven by 15-hp. Westinghouse motor	Link-Belt Co.
1	Conveyor	Continuous-bucket	24x24-in.	Deliver coal to bunkers	Driven by 30-hp. Westinghouse motor	Link-Belt Co.
1	Heater	Open	8 ft. dia., 35 ft. high	Heat feed water	Filled granite boulders, counter-current	Home-made
				Equipment of 6,000-Hp. Plant		
12	Boilers	Water-tube	500-hp.	Generate steam	Pressure, 80 lb.; stokers, natural-draft	Henry Vogt Machine Co.
12	Stokers	Chain-grate	132-sq.ft.	Serve boilers	Driven by 8x8-in. Wachs engine or 30-hp. Westinghouse motor	Illinois Stoker Co.
2	Stacks	Reinforced-concrete	14x250-ft.	Serve boilers		General Concrete Construction Co.
1	Pump	Centrifugal	6-in. discharge 1,350-gal. per min.	Water from storage to heaters	Driven by 40-hp. Westinghouse turbine	A. S. Cameron Steam Pump Works
2	Pumps	2-stage centrifugal	1,350 gal. per min.	Boiler-feed pumps	Driven by 150-hp. Westinghouse turbine	A. S. Cameron Steam Pump Works
1	Elevator	Hydraulic	One-ton	From basement to boiler-room floor		Otis Elevator Co.
1	Pump	Duplex	10x6x10-in.	Serves elevator		National Transit Co.
1	Pump	Duplex	10x6x10-in.	Boiler washout		National Transit Co.
2	Pumps	Duplex	7½x5x10-in.	Feed oil to boiler furnaces		National Transit Co.
2	Governors	Excess-pressure		On boiler-feed pumps		Erie Pump & Equipment Co.
1	Governor	Constant-pressure		On circulating pump		Erie Pump & Equipment Co.
2	Heaters	Open	8 ft. dia., 35 ft. high	Heat feed water	Filled granite boulders counter-current	Home-made
2	Feeders	Plate		Coal from track hopper to belt conveyor	Driven from foot shaft of conveyor	Jeffrey Manufacturing Co.
1	Crusher	Single-roll		Crush coal	With conveyors driven by 30-hp. Westinghouse motor	Jeffrey Manufacturing Co.
2	Conveyors	Belt	30-in. wide	Coal from feeders to elevators	Both driven through jackshaft by 30-hp. motor	Jeffrey Manufacturing Co.
2	Elevators	Bucket	18x9x12x$\frac{3}{16}$-in.	Elevate coal above bunkers	Both driven by 30-hp. Westinghouse motor	Jeffrey Manufacturing Co.
2	Conveyors	Belt	20-in. wide	Coal from elevators to bunkers	Both driven by 15-hp. Westinghouse motor	Jeffrey Manufacturing Co.
1	Conveyor	Belt	16-in. wide	Returns green coal to elevators	Driven by 3-hp. General Electric motor	Jeffrey Manufacturing Co.

as it is necessary to put a 24-hr. supply of coal (500 tons) into the overhead storage bunkers in half a day. The same track is the only means of access to other parts of the plant and is used daily in getting shipments in and out. Ample storage for surplus coal is provided for in another section of the yards.

The hopper has two reciprocating plate feeders, each delivering to a belt conveyor, which in turn either delivers to a single-roll crusher or through a bypass to either of two vertical double-strand chain-and-bucket elevators.

The elevators deliver to overhead belt conveyors, Fig. 5, which have traveling self-propelling trippers for distributing coal to the bunkers. From the bunkers the coal is fed by gravity through spouts directly to the stoker hoppers, the flow of coal being regulated by gates controlled by chains from the boiler-room floor.

The track hopper is of steel plates reinforced with angles. A 3-in. mesh steel-bar grating covers the hopper to prevent workmen about the yards from falling into the opening when the hopper is not in use. The grating is in sections, so that it can be removed easily when large coal is being unloaded. Hinged doors over the top of the hopper are also provided to prevent snow, ice, etc., from accumulating in it during the colder weather. To make it water-tight the track-hopper pit is lined with a steel tank.

The plate feeders, each independently driven from the foot shaft of the conveyor it feeds, are arranged to handle both large and small coal. The driving cams, or eccentrics, are adjustable, so that the feed to the belt conveyors may be regulated. The latter are made up of 30-in. heavy rubber belts carried in standard three-pulley troughing idlers and flat return idlers. This width of belt was selected because at times it will be necessary to handle large lump coal. A solid steel plate between the carrying and return runs of the belt keeps the pulley side of the belt free from dust and dirt. Each conveyor has a clutched drive from a main jackshaft. The speed of the belt is 200 ft. per min. The crusher also has a clutched drive from this same jackshaft. It is of the single-roll adjustable design, so that it is possible to prepare at one operation any size of coal desired for the stokers.

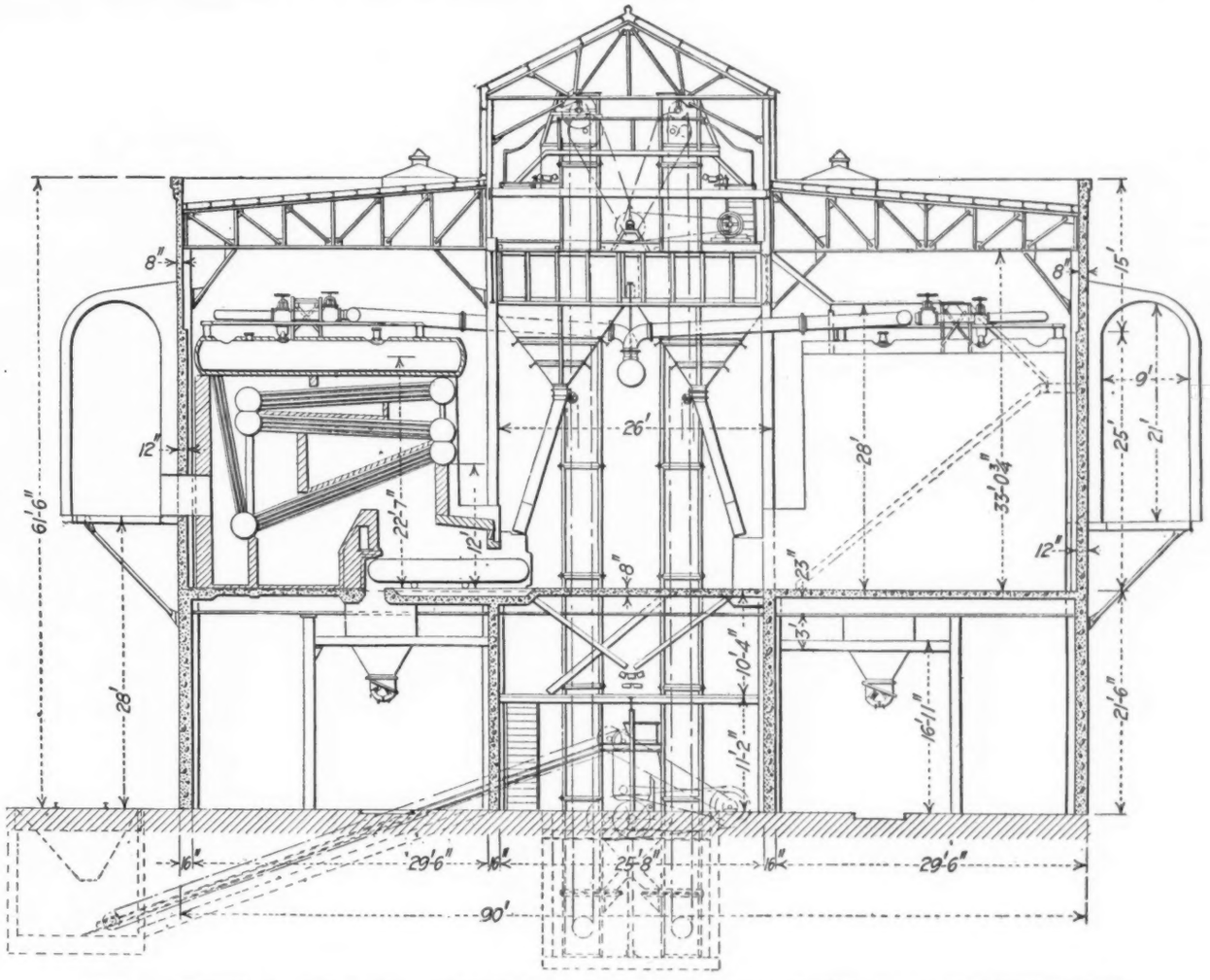


FIG. 7. SECTIONAL VIEW OF BOILER HOUSE, SHOWING DUPLICATE COAL-HANDLING EQUIPMENT

The elevators, on 70-ft. vertical centers, are made up of 18x9x12$\frac{3}{16}$-in. steel continuous-type buckets mounted on two strands of square-shank pin chain. Each is driven from a common jackshaft at a speed of 120 ft. per min.

The conveyors over the storage bunkers are made up of heavy rubber belting 20 in. wide. They have 135-ft. centers and operate at a speed of 200 ft. per min. Each has a clutched drive from a common jackshaft. The trippers are of the self-propelling reversible type, which

can be locked to deliver continuously at any given point or may travel slowly forward or backward over either a section of the bunker or its full length.

The storage bunker, which has a capacity of 850 tons, is steel supported by columns resting on concrete piers. Curtain walls from the top of the bunker to the building roof prevent coal dust flying about the boiler room. The valves and spouts are also practically dust-tight.

Each elevator and conveyor can handle 60 tons of coal per hour, so that when the whole outfit is in use, it will deliver 120 tons per hr. With either unit disabled the other can keep the bunkers filled with coal.

Ashes fall from the rear of the stoker directly into a firebrick-lined steel hopper that is large enough for about a 24-hr. run. The bottom of the hopper has a 28x28-in. gear-lever type of cast-iron clamshell valve. In the basement under each row of hoppers a track is laid, so that the ashes may be dumped directly into railway cars, for which there is ample headroom under the valves.

Concrete slabs under the stokers catch the fine or green coal falling through the grates. This is raked to the front of the stoker into a chute which discharges upon a 16-in. belt conveyor, Fig. 8, located on the basement floor. This conveyor delivers to the vertical elevators previously mentioned, so that the fine coal eventually finds its way back to the bunker.

For the new plant the boiler-feed supply also comes from the oil condensers and is stored in two 400,000-gal. tanks, which are 50 ft. diameter and 30 ft. high. There are two feed-water heaters of the type used at the older plant. They are operated in parallel, and each has a large storage tank underneath. A turbine-driven centrifugal pump transfers the water from the initial storage tanks to the heater, and two-stage centrifugal pumps feed it into the boilers. The latter are piped so that either may be used in place of the circulating pump. They are controlled by excess-pressure governors that maintain the water pressure 35 lb. above the steam pressure. The circulating pump has a constant-pressure governor.

To control the level of the feed water in the storage tank of the feed-water heater, an interesting device has

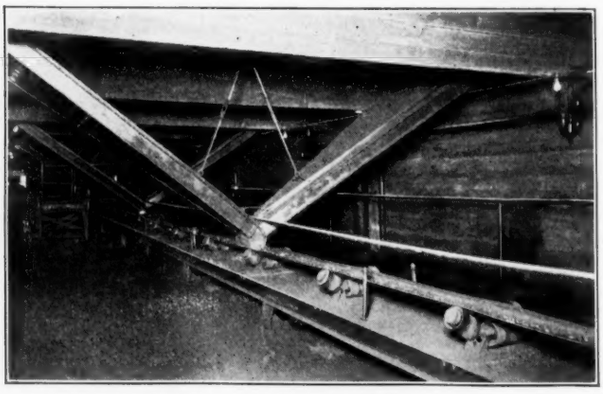


FIG. 8. GREEN COAL CONVEYOR IN BASEMENT

been perfected by the engineering department at the works. As shown in Fig. 9, it is a balanced valve mounted in the discharge line of the circulating pump. On one end of the balance arm is a small reservoir attached to the storage tank by flexible tubing. Water enters through the bottom tube, and when it rises to a predetermined level in the reservoir, it overbalances the counterweights on the other end of the arm. A downward movement of the reservoir closes down on the valve and reduces the supply to the heater, but it has been arranged so that the valve cannot be completely closed. When the water level falls in the storage tank, the counterweights over-

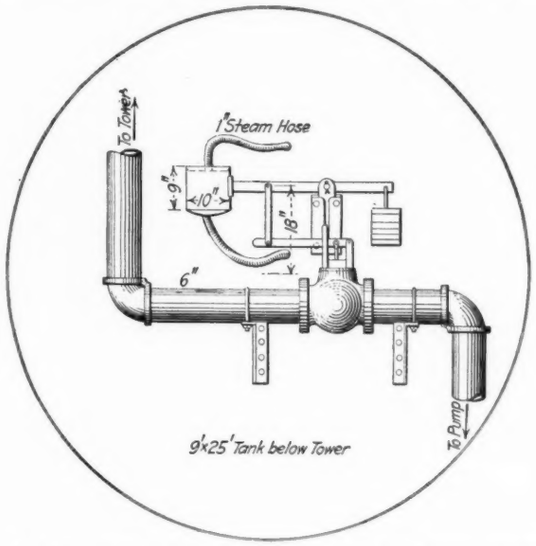


FIG. 9. HOME-MADE FEED-WATER REGULATOR

balance the reservoir and open the valve wide. The position of the valve affects the pressure in the supply line to the heater and causes the pump governor either to slow down or accelerate the speed of the turbine driving the pump. The upper flexible tube allows the air to escape from the reservoir into the tank, so that the water may have free entrance.

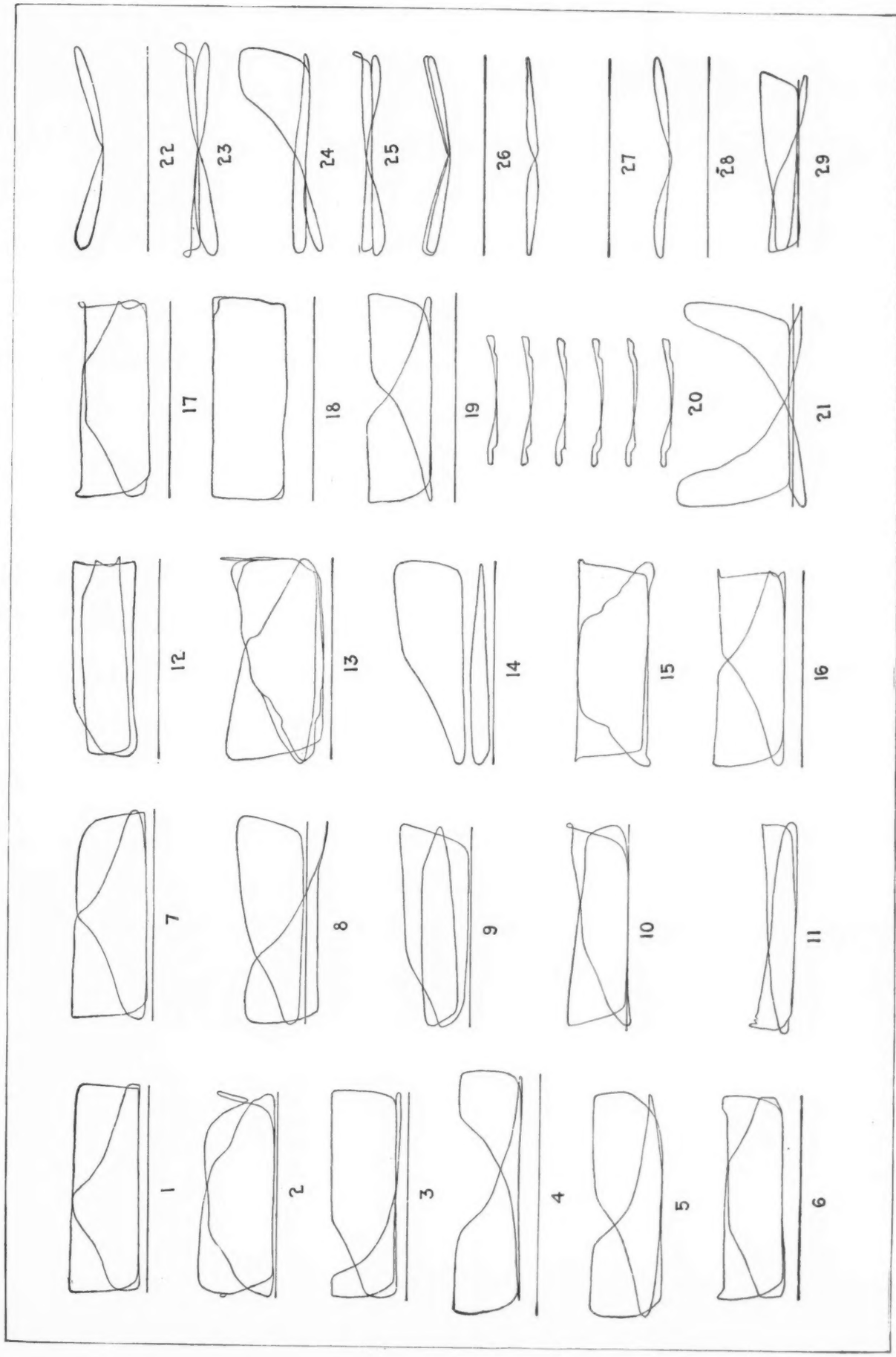
As the new plant has just been put into operation, no operating data are available, nor has the acceptance test been conducted. High economy and the ability to operate at large overloads are expected. The plant was designed and constructed under the supervision of the engineering department at the works.

Dynamite Releases Water

One of the most intricate and daring tasks in the history of hydro-electric power development was completed Feb. 15 at Juneau, Alaska, when more than a ton of dynamite released water sufficient to generate 12,000 hp. for the mining plant of the Alaska-Gastineau Mining Co. there. Incidentally the releasing of the water power enabled the company to increase its gold output from $5,000 to $15,000 per day.

To increase the capacity of the generating plant of the mine, the engineers determined to use the water of Annex Lake, 1½ mi. long by ¼ mi. wide and 200 ft. deep, at Taku Inlet, 18 mi. from the generating plant of the mine. Under the direction of the vice-president of the mining company, Col. D. C. Jackling, who conceived the idea, and supervised by B. L. Thane, manager, and H. L. Wollenberg, chief engineer, a tunnel was driven for a distance of 1,200 ft. under a mountain that formed a natural barrier to the waters of the lake.

So careful and accurate had been the figuring on the Annex Lake projects that nothing was left to chance. The turbines were built, the tunnel was constructed, the pipe line laid, the steel towers erected and the power line installed. The tunnel was completed to within 6 ft. of the solid rock bottom of the lake, when drills were installed to bore holes for dynamite. Seventy-five holes were drilled in the bottom of the lake above the tunnel. The wires were attached, and in less than two minutes after the explosion the turbines in the generating plant were turning. A 42-in. pipe line 2 mi. long is used in connecting up the power house, which now generates 18,000 hp. The whole development cost a little more than $500,000. The entire mining plant cost $5,000,000.



DEFECTIVE INDICATOR DIAGRAMS FROM CYLINDERS, VALVE CHAMBERS AND RECEIVERS; ACCUMULATED IN YEARS OF PRACTICAL ENGINEERING EXPERIENCE
Contributed by J. W. De Vore, Columbus, Ohio

Quantities of Ammonia for Refrigeration

By A. G. Solomon

SYNOPSIS—Why the theoretical quantity of ammonia to effect a given quantity of refrigeration will not do so in practice. This article is intended for beginners and operators who do not understand the way to proceed to calculate ammonia compressor capacities.

It is a common mistake for operating men to take for granted that the cylinder of an ammonia compressor fills with vapor having the same temperature as that in the evaporating coils and suction line. To remove heat from brine in a tank or from produce in a room ammonia has to be evaporated. This evaporation is caused by the absorption of the heat by the ammonia. The greater the number of heat units carried by the ammonia the greater the quantity of refrigeration produced. Also the greater the weight of liquid ammonia changed into vapor the greater the refrigerating effect.

The refrigerating plant is divided into three parts: The evaporator, or place where the heat is taken up to vaporize the ammonia; the compressor, where the latent heat is converted into sensible heat and sent to the condenser; the condenser, where the ammonia is relieved of its load of heat and changed into liquid. The capacity of the plant depends on the amount of ammonia it is possible to take from the evaporator and put into the condenser. Therefore the compressor controls the capacity.

The weight of ammonia is the chief consideration. To remove a given amount of heat, a certain number of pounds of liquid ammonia must be evaporated. At 30 lb. abs. a pound of ammonia will require 572.1 B.t.u. to change it from liquid to vapor. This means that at that pressure a pound of ammonia is capable of absorbing and carrying 572.1 B.t.u.

If the liquid admitted to the evaporating coil has the same temperature as the vapor in the coil, the whole load of heat is taken from the substance to be refrigerated. In the case under discussion the temperature would be 0.1 deg. to correspond with 30 lb. abs. pressure, if the heat transfer were perfect.

The Specific Heat a Factor

In ordinary practice the temperature of the ammonia passing the expansion valve is not the same as the temperature in the evaporating coil, but is that of the cooling water flowing over the condenser. If the cooling water is 80 deg. and the ammonia is so handled that its temperature is 80 deg. at the expansion valve, the difference (79.9 deg.) must be absorbed by the ammonia itself before useful work is begun.

Then 572.1 — 79.9 = 492.2 B.t.u. is the amount of heat each pound of ammonia that passes into the evaporating coils will take from the substance to be refrigerated. This is true if we consider the specific heat of liquid ammonia as 1, as is usually done. But the specific heat is 1.14. This value is an average of all the values determined by Dieterici.

Then 79.9 × 1.14 = 91.086, the number of heat units taken from each pound of ammonia passing the expansion valve before useful work is begun, and 572.1 — 91.086 = 481.014 B.t.u., the amount of heat it is possible for 1 lb. of ammonia to absorb under the given conditions. To produce this quantity of refrigeration all the liquid must be changed to a dry vapor, which still has the temperature corresponding to the pressure at saturation. This load of heat is now ready to go to the compressor. As it leaves the evaporator the pound of vapor occupies 9.17 cu.ft., has a pressure of 30 lb. absolute and a temperature of 0.1 deg. F.

So far the ammonia has been handled in a theoretical manner and we know that the figures are correct.

Perfect Conditions Never Met

If it were possible to have a perfect compressor and perfect insulation and means of removing the heat of compression, so that no heat was added to the vapor, a pound of ammonia would be sent to the condenser every time the piston displaced 9.17 cu.ft., but such perfect conditions are never met.

It is possible to have the suction line between the evaporator and the compressor so well insulated and the ammonia so handled that a thermometer inserted in the suction line close to the compressor will show a temperature of 0.1 deg. when the back pressure is 30 lb. abs. However well-insulated and water-jacketed the compressor may be, the temperature of the ammonia will increase in its passage into the cylinder. The suction valve, piston, cylinder head and cylinder walls have a temperature much higher than the incoming ammonia.

The ammonia at the end of the suction stroke will not be a saturated vapor, but a superheated gas. Just what the degree of superheat will be will depend on the condition of the compressor. In a single-acting dry-gas machine this temperature is generally 100 deg., at which each pound of superheated gas occupies 11.55 cu.ft. If the superheat should be 150 deg.—and it often is—the volume will be 12.65 cu.ft. to the pound.

Vapor Is Superheated in Cylinder

As it is impossible to prevent superheating in the cylinder, the only thing to do is to keep the superheat as low as possible. Have the ammonia reach the compressor in the greatest degree of saturation permissible with the type of machine and the operating conditions. A thermometer inserted in the suction line close to the compressor should show a temperature corresponding to the suction pressure. If the machine is vertical, single-acting and has a full-length water jacket, the bottom two-thirds of the jacket should be filled with a mixture of granulated cork and cement if necessary. This will set hard, and water will not penetrate it; it is an excellent insulating material. Through the top third of the jacket as much water as possible should be circulated to remove the heat of compression. The water flowing through the jacket should at no time impart heat to the ammonia.

The effective displacement of a compressor is seldom over 85 per cent. of the cubical content of the cylinder. The other 15 per cent. is accounted for by reëxpansion of the gas in the clearance spaces, and valve and piston leakage. At that rate, to pump 1 lb. of vapor at 30 lb. pressure and 0.1 deg. temperature, the cylinder area must be 9.17 cu.ft. plus 15 per cent., or 10.5455 cu.ft. But as the ammonia is superheated 100 deg., the area through which the piston must travel to send a pound of ammonia to the condenser is 11.55 + (15 per cent. of 11.55) = 13.2825 cu.ft. We have learned that it is practically impossible to prevent superheating.

If each pound of ammonia is capable of taking 481.014 B.t.u. from the substance to be refrigerated, then $\frac{287,000}{481.014}$ = 596.6 lb. of ammonia is pumped in 24 hr. to produce 1 ton of refrigeration under the conditions given. The weight handled per minute will be $\frac{596.6}{1,440}$ = 0.413 lb.

To sum up, 13.2825 × 0.413 = 5.4856 cu.ft. of piston displacement will be required per minute to produce 1 ton of refrigeration in 24 hr. when the temperature of the liquid ammonia is 80 deg. F. and the temperature in the evaporator is 0.1 deg.

Economizer Safety and Repairs

By S. H. Farnsworth

SYNOPSIS—Methods of safe economizer operation and handy repair are related which should be of value to engineers. The arrangement of various connections point to safety in economizer operation.

This article relates to the safety and repair methods found of value in the operation of economizers, by the author. The chart, Fig. 1, shows a peak at 8:50 a.m. caused by an explosion of gas in an economizer setting. The main damper between the stack and the economizer had been closed some time previously, but the mechanism for controlling the speed of the stoker engine had failed to work, allowing the coal to be fed to the furnace while an insufficient supply of air was being admitted for proper combustion, thus forming carbon monoxide, which accumulated in the economizer setting. As the damper opened, the gas caught fire. There was a loud roar, and the doors were blown open. The free path for the escape of the ignited gas prevented serious damage.

It seems that a safer arrangement for the draft-controlling damper would be to place it in the flue entering the economizer, as there would be less space for the storage of explosive gas and a free path for its escape in the event of an explosion. Every safeguard against accident should be taken.

Both the inlet and outlet dampers should have means for locking them in position, so that gas cannot be turned on the economizer while men are working in the setting. Only the man in charge of the work at that particular time should have a key.

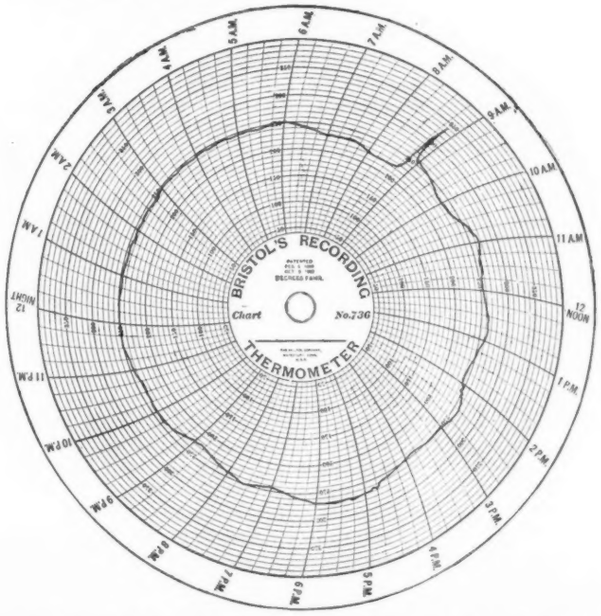


FIG. 1. PEAK ON CHART INDICATES GAS EXPLOSION

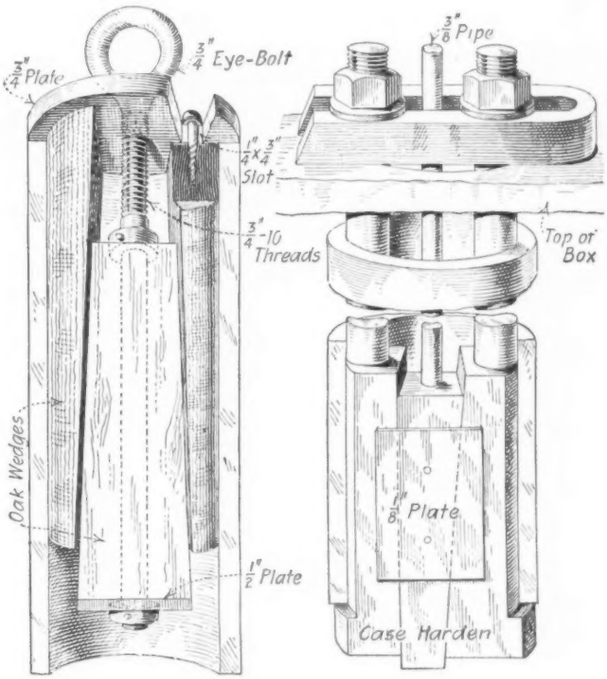


FIG. 2. TUBE SHACKLE

FIG. 3. TUBE PULLER

A door 1 ft. 6 in. by 4 ft. should be provided in the soot chamber. Crawling through the small 16-in. holes should be condemned, as a man entering for inspection or cleaning might die from gas or scalding before he could get out, should an accident occur. A door of the same size should be provided at the entrance to the tube chamber, and a door 1x6 ft. at the opposite end of the setting to allow a circulation of air. The latter opening should have a grating to prevent anyone falling through when the door is left open.

If the feed pumps are in duplicate, their respective discharge pipes should continue to the economizer inlet and have a check valve at this point, independent of the check valve on the economizer.

The inlet valve should be accessible, and there should be no danger of scalding a man by hot water running along the floor should a tube burst. This can be accomplished with an extension stem using bevel gears if necessary.

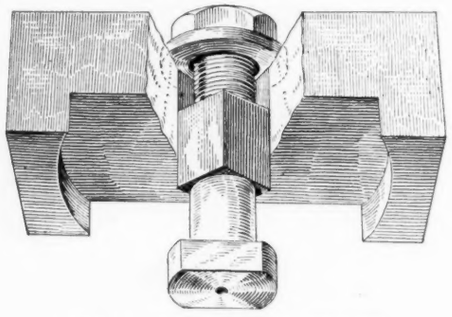


FIG. 4. THE PLATE PULLER

There should be two valves in series to obviate the danger of the economizer being emptied by an obstruction, making it impossible to close the blowoff valve. The vent valves should be at the outlet end of the economizer and faced away from the ladder or stairway.

The safety valve can be kept tight and still be safe by removing the bonnet about every two months and cleaning and oiling all parts. The outlet pipe of the valve should discharge toward the floor and be placed in such a position that no one will be scalded if the valve opens, which should be a rare occurrence if it is set to blow at 10 per cent. over the boiler pressure.

A 12-in. I-beam should be riveted to the roof, trussed and extended out over the end of the economizer setting to carry a chain block and trolley. This will pay for itself before the economizer is put into operation and will also pay a good rate of interest on the cost each year thereafter.

The practice of using rope blocks slung from wire spans is unsafe and expensive. There is always danger of the rigging being poorly erected. The span may be poorly

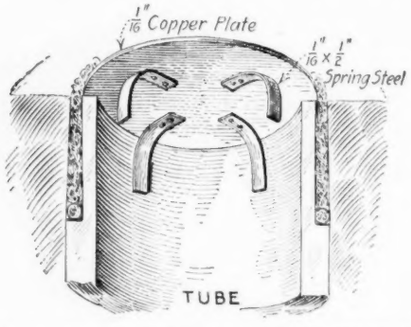


FIG. 5. PLATE USED IN MAKING RUST JOINT

lashed and a piece of cable used that has seen considerable service. Then there is always the possibility of the men falling while doing the rigging. When attaching a section to be raised, a $\frac{5}{8}$-in. wire rope should be used and passed through at least four tube diameters of the top box.

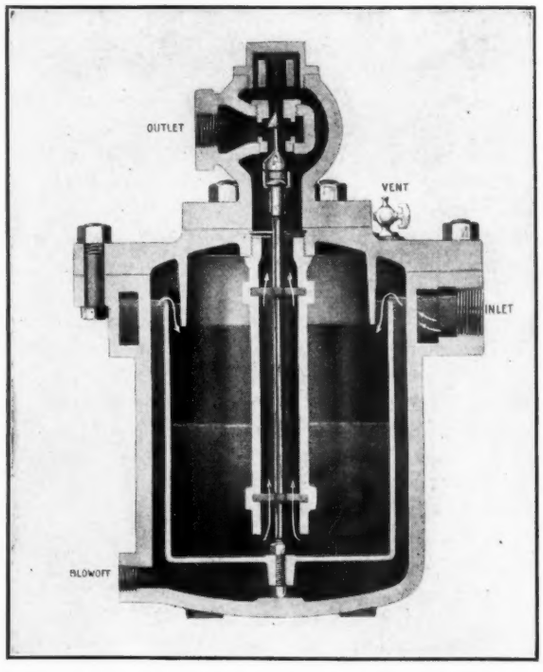
The top boxes are usually broken by trying to knock out pieces of tube after it has been chipped. If four $\frac{5}{16}$-in. holes are drilled in the top of the tube, 3 in. deep and 45 deg. apart, it can be broken away without endangering the box. It is only necessary to break away half of the top of the tube. Bottom boxes are broken by trying to pull out rusted tubes. The tube puller shown in Fig. 3 equalizes the strain and prevents the tube shank from wedging.

A fire of charcoal built under the bottom box in line with the tube to be pulled will help in stubborn cases. Care must be taken to keep water out of the section while it is hot, or it will be cracked. Fig. 4 is a plate puller.

The shackle shown in Fig. 2 is for lowering the new tube into place. The plate shown in Fig. 5 is helpful in filling and calking the rust joint. A crab and bolt are used for tightening the tube covers. These tools were designed by the author and are appreciated by the men who use them.

Stickle Balanced-Valve Steam Trap

To its series of bucket steam traps for high- and low-pressure service, the Open Coil Heater and Purifier Co., of Indianapolis, Ind., has recently added a balanced-valve steam trap for use where a large quantity of water is to be taken care of. It is made for high- and low-pressure



SECTION THROUGH BALANCED-VALVE STEAM TRAP

service in sizes varying from a $\frac{3}{4}$-in. outlet to 2-in., the capacity ranging from 300 to 3,400 gal. per hr.

The construction is shown in the sectional view. It differs from the standard trap only in its discharge valve, which is of the double-ported type and allows several times as much condensation to escape as the single valve in the standard trap. This is due to the larger area permissible when the valve is practically balanced and also to the double outlet for the water. To prevent the valve from scoring, the bucket rotates when the trap discharges, turning the valve on its seat.

Air Circulation conveys heat away from bearings in proportion to its amount, specific heat and temperature increase.

Draft in Fire-Tube Boilers

By S. H. Viall

SYNOPSIS—A study of draft conditions observed in five series of tests. Effect of arch construction, furnace temperature and the areas of the tubes, uptake and gas passages.

In the Mar. 2 issue of *Power,* page 396, a description was given of five series of tests made on a 66-in. by 16-ft. return-tubular boiler. A different hand-fired furnace was used in each series, and from the test data certain conclusions were reached. In the present article the draft conditions of the last three, or the C, D and E series, will be studied. It will be remembered that the first and second series of tests were made on a full-extension firebrick-inclosed furnace. For the last three series the dutch oven was torn out and the setting made flush front. During the tests upon the full-extension furnace, records were not kept of the draft conditions in the combustion chamber, and on this account will be disregarded.

Table 1 gives the draft data in inches of water, the draft loss through the boiler and the rate of coal consumption per square foot of grate surface per hour for the five series of tests. Curves *X* of Fig. 1 are a graphic representation of the draft data for tests C, D and E. The curves show the drop in draft from the stack side of the damper plate to a point over the fire. In each case the fuel bed was made up of free-burning noncaking coal from Indiana and was about 6 in. thick. Curve *C* shows the draft conditions for the plain setting shown in Fig. 2, curve *D* for the setting with the deflection arch behind the bridge-wall, as shown in Fig. 3, and curve *E* for the double-arch bridge-wall furnace shown in Fig. 4.

Function of the Deflection Arch

Referring to Figs. 3 and 4, it will be seen that the furnace gases, after passing over the bridge-wall, were compelled to turn downward before they could pass under the deflection arch. The additional arch construction was installed to maintain a zone of high temperature behind the bridge-wall and obtain a more intimate mixture of the volatile gases and air to reduce the smoke.

When the suggestion is made of trying arches such as those shown, many engineers will hesitate. They argue that there must be a marked loss in draft, with accompanying troubles, because of the additional twists and turns the gases must make between the fire and the rear tube sheet. The curves of Fig. 1 show that the loss in draft between the combustion chamber and the fire is practically the same in each case, and tend to prove that the arch construction used in these tests did not materially interfere with the passage of the gases.

In the furnace constructions shown in Figs. 3 and 4 there are three openings between the furnace and the combustion chamber. The first opening is between the top of the bridge-wall and the lower line of the boiler shell, or the underside of the double arch of Fig. 4. The second is the horizontal opening between the rear face of the bridge-wall and the front face of the deflection arch. The third opening is between the top of the firebrick pavement of the combustion-chamber floor and the under side of the deflection arch. If any of these openings are too small, friction may cause an excessive draft loss.

From practice it has been worked out that these openings should bear ratios of 25, 40 and 50 per cent. to the grate area, respectively. Passages proportioned as suggested will be found satisfactory for rates of coal burning of from 15 to 30 lb. per sq.ft. of grate per hour.

In the boiler there were fifty-four 4-in. tubes having an aggregate internal area of approximately 594 sq.in. The free opening through the smallest part of the uptake had an area of 612 sq.in., which, with no damper in the opening, is 103 per cent. of the combined tube area. A damper hung in the usual position would have reduced the free opening to about 96 per cent. of the tube area, but the damper happened to be set in a leg of a pants breeching. In building return-tubular boilers it is common to make the damper opening about equal to the tube area. This is so general that engineers seldom think of asking what effect the uptake opening will have upon the draft available over the fire. The curves of Fig. 1 show that the loss in draft may be greater from the stack side of the damper plate to the flue caps than it is through the combustion chamber. Evidently it is important to look to the size of the uptake. Considering the draft in the uptake, on the stack side of the damper plate for the C, D and E tests as 100 per cent. and expressing the draft at the other points as a percentage of the draft available at the uptake the results presented in Table 2 are obtained. In the fourth column are average draft conditions through return-tubular boilers using natural draft and having uptakes about the same size as the internal tube area. The herewith data are averages from many hundreds of draft investigations on return-tubular boilers of all sizes. Increasing the damper opening 25 per cent. reduces the loss in the uptake, as shown in the fifth column of this table. These data are from double-arch bridge-wall furnaces, such as is shown in Fig. 4.

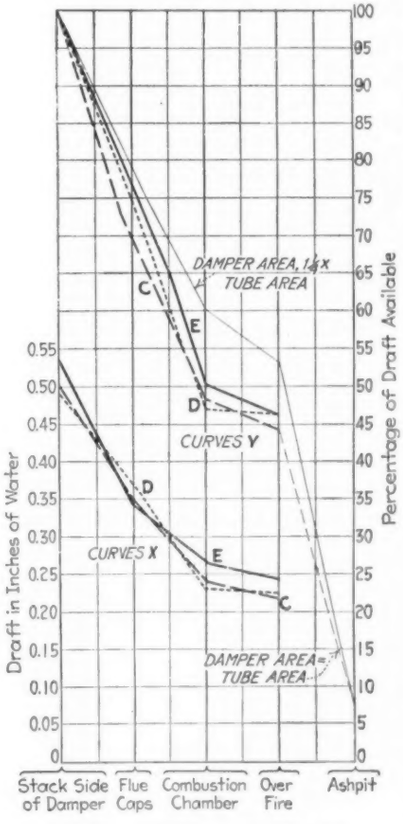


FIG. 1. SHOWING DRAFT LOSSES IN TUBULAR BOILER

From curves *Y* of Fig. 1 it will be noticed that the large damper results in 9 per cent. more draft over the fire even with additional furnace arches, causing the gases to make three extra right-angled turns. Practically all the gain is due to the lower drop through the damper. With a damper opening 1¼ times the tube area, the average loss in draft from the stack side of the damper to the flue caps is about 21 per cent.

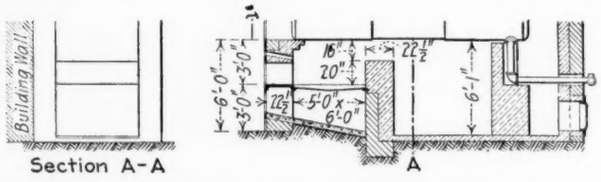


FIG. 2. THE USUAL PLAIN BOILER SETTING

Five to six per cent. appears to be the commercial minimum to which this loss can be reduced by using dampers having 175 per cent. of the tube area and a smoke box designed to give ample space for the gases to turn from horizontal to vertical travel.

The draft data given in Tables 1 and 2 are for boilers operating at capacity or above, with fuel beds 6 to 7 in. thick of free-burning noncaking coal. Columns 4 and 5 of Table 2 apply to fires of caking coals only when the fuel bed is open, as it is just after hooking and shaking of the grates.

The foregoing remarks are at variance with the ideas of some engineers, who reason that the tubes offer the greatest resistance to the furnace gases, owing to the large number of small passages having large friction surface. Thus, if the passages in the combustion chamber are a little larger than the combined tube areas and the dampers and breechings are almost as great, they are considered ample.

The tubes are arranged so as to break the gases up into streams of small cross-section to extract heat more effectively. Loss of draft caused by the work done in moving the gases through the tubes is compensated for by the transfer of heat to the water and the consequent reduction in volume of the gas. The passages for the gases before reaching and after leaving the heat-absorbing surfaces should be large enough to allow their movement with minimum friction. The use of deflection arches on baffling piers is warranted when the benefits derived are more valuable than the evils due to the draft loss they cause. Excessive friction by the moving gases between the boiler and the top of the stack is bad, as it seriously limits the capacity that can be developed by the boiler. Excessive friction in the spent gases should be guarded against as jealously as tight bearings on an engine.

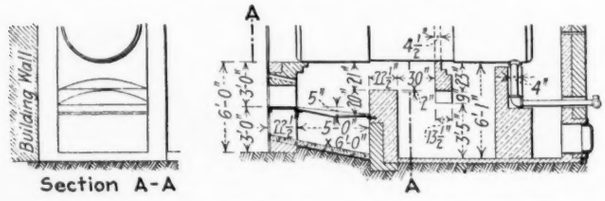


FIG. 3. DEFLECTION ARCH BACK OF BRIDGE WALL

Dividing the pounds of coal (as fired) burned per hour per square foot of grate, given in Table 1, by the draft over the fire, it will be seen that the firebrick-inclosed furnaces used in the A and B tests burned approximately 2 lb. of coal per hour per square foot of grate surface for each 0.01 in. of draft over the fire. During the C, D and E tests approximately 1 lb. of coal per hour was burned per square foot of grate for each 0.01 in. of draft over the fire. These data clearly illustrate the fact that a greater quantity of bituminous coal can be burned with a given draft intensity over the fire in a firebrick-inclosed furnace than in a furnace cooled by the radiation of heat to the absorbing surface directly above the grates. The highly heated firebrick surfaces inclosing a dutch-oven furnace radiate heat to the fuel bed. Fresh coal thrown into the furnace is exposed to the heat from the fuel bed below and from the firebrick above. This causes a quick rise in the temperature of the fresh pieces of coal, resulting in rapid distillation of the moisture and volatile matter. The fixed carbon will burn readily because of the high temperature.

TABLE 1. DRAFT READING FOR FIVE SERIES OF TESTS ON A RETURN-TUBULAR BOILER

	Series A	B	C	D	E
Type of furnace, Fig. No.	2	3	4	...	...
Draft at stack side of damper, in.	0.38	0.51	0.50	0.49	0.535
Draft at flue cap doors, in.	0.212	0.232	0.35	0.37	0.345
Draft in combustion chamber, in.	....	....	0.24	0.23	0.268
Draft over fire, in.	0.116	0.113	0.22	0.226	0.245
Percentage of available draft lost through boiler	70	77	57	54	56
Coal as fired per square feet of grate, lb.	22.63	24.62	24.7	24.8	26.6

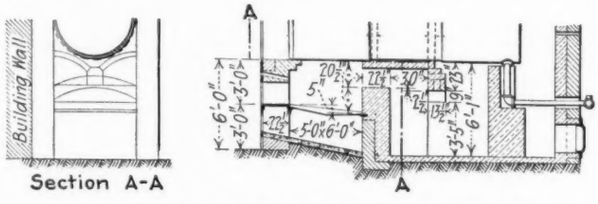


FIG. 4. BOILER FURNACE WITH DOUBLE ARCH

Although bituminous coal, hand-fired, can be burned more rapidly in a firebrick-inclosed furnace, it cannot always be burned with as good economy as in the "cooler" types of construction. This phase of the subject does not properly come within the limits of this discussion and will be treated in another article.

Behind the bridge-wall of dutch-oven furnaces the temperature may be 600 to 900 deg. higher than for like rates of combustion and similar grades of coal in other types of furnace. Assume the same weight of gas per unit of coal in each case. Then the gases in the firebrick-inclosed furnace must travel at a higher velocity than in the cooler furnaces, because of the increased volume of gas per unit of weight resulting from the higher temperature. The higher velocity results in greater friction, causing a greater draft loss through the combustion chamber and over the bridge-wall. The difference in velocities of the furnace gases was the principal factor causing the variation in draft loss through the settings between tests A and B, and the C, D and E series.

TABLE 2. PERCENTAGE OF DRAFT THROUGH BOILER AND SETTING

	Tests, Series C	D	E	Average Draft — Damper = Tube Area	Damper = 1¼ Times Tube Area
Type of furnace, Fig. No.	2	3	4	...	...
Stack side of damper	100	100	100	100	100
Flue caps	70	75	65	70	79
Combustion chamber	48	47	50	48	60
Over fire	44	46	46	44	53
Ashpit	..	..	..	7	7

Numerous false ideas of the influence various factors have upon draft would be corrected if engineers were to carefully study conditions in their plants, using for this purpose differential draft gages built to read in hundredths of an inch. Incidents similar to the following will be less frequent when this is done.

A visitor standing in the boiler room of a progressive company was talking to the chief engineer, who was considered a capable man and was well paid. The visitor was informed that there was ¾ in. draft at the plant. In answer to questions as to where the draft readings were taken, the engineer responded by pointing to a breeching that served six 150-hp. return-tubular boilers and said, "Up there." He was then asked how much draft he had over the fires. He informed his questioner that he had never taken draft readings over the fires, but volunteered the information that it would be a little better than ¾ in. because the fires were about 15 ft. lower than the breeching. The visitor was assured that the engineer would be pleased to do anything to accommodate him, so upon leaving, he asked the engineer to find out what the draft was over the fire, and if it was not as much as in the breeching, to find out where the difference occurred and let the inquirer know the results at the time of his next call.

Prevents Low Water and Overpressure

By Frank C. Perkins*

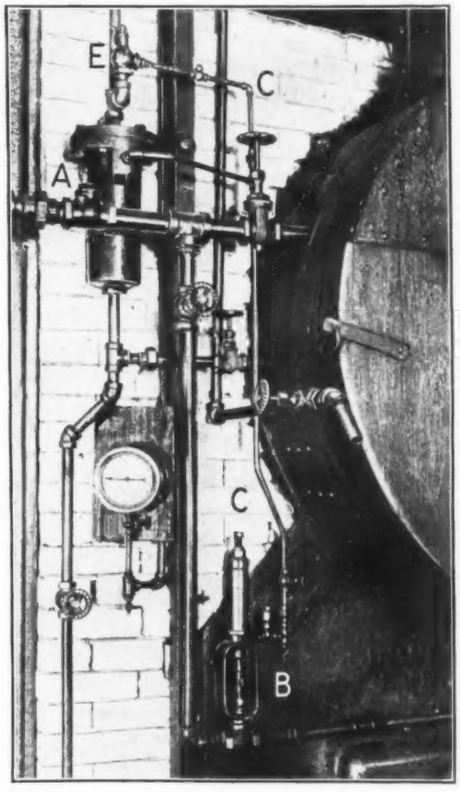
The illustration shows interesting boiler safety appliances developed at Everett, Wash. It will be noticed that *A* is a column connected to the boiler with both water and steam connections the same as any ordinary water column, and that the ridge cast on the column indicates where it is to be set in relation to the lowest safe level of water. When water reaches this level in the boiler, the float in the column operates a needle valve which admits steam through the brass-pipe *C* to the piston-operated valve *B*, which admits water and steam through *B* and into the firebox, extinguishing the fire. When water in the boiler has been brought up to the safe level, the needle valve shuts off and valve *B* closes. The ½-in. spring-incased relief valve *E* is for the purpose of protecting the boiler from a dangerous increase in pressure. It can be put on the boiler shell or in the main steam line or the steam line to the column as shown. It is a spring-loaded valve and set for 5 lb. above the pressure for which the safety valve is set. If, for any cause, the latter sticks and does not release at the pressure at which it is set, the valve *E* opens and admits steam to valve *B* through *C* and extinguishes the fire.

Both of these appliances may be tried out each day by simply blowing down the column and seeing if valve *B* operates. It is not, of course, necessary to put the fire out when trying the valve, as it starts moving slowly and water can be admitted to the column before the fire is deadened. Simply pulling the lever on valve *E* operates valve *B* in the same manner as blowing down the column. Valve *E* is set and locked with the inspector's seal.

When oil is used for fuel, valve *B* is placed in the oil line to the furnace, stopping the oil supply to the burners when the boiler is in danger from either low water or overpressure. One of these appliances has been tested by blowing down the boiler through the blowoff valve while under full load and pressure and with a heavy fire. The appliance has been set to operate just as water was going out of sight in the water glass, and the fires have been put out instantly. When applied to a boiler burning fuel oil, it simply shuts off the oil to the fires and does not admit steam and vapor to the firebox.

The water blown into the firebox is of the temperature of steam, and when released to atmospheric pressure it flashes into a heavy vapor, putting the fire out and blackening the walls; cracking of the walls or grates does not occur.

I understand that fear has been expressed about taking water from a boiler whose water level is already



DEVICES FOR PREVENTING LOW WATER AND OVERPRESSURE

dangerously low. The amount required to deaden the fire and hot brickwork is small, and after the first discharge from the nozzles it is immaterial whether all the remaining water in the boiler is blown out or not, as no damage from burning can result, and at the same time pressure is being reduced as long as the valve remains open.

If for any cause the safety valve sticks or the pressure increases so rapidly that this valve cannot handle it, the small valve *E* will operate and extinguish the fire as in the case of low water. The apparatus is superior to fusible plugs, as by simply blowing down the column the operator can determine at any time whether it is in working order. After it has operated, the fire may be started immediately upon the safe water level being attained.

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The Influence of Compression in Internal-Combustion Engines

By R. E. Mathot

SYNOPSIS—It is shown that within certain limits neither the amount of compression nor the heat value of the fuel affects the output of the engine; the former does, however, influence the economy. Also, tables are included which give the proper mixtures and compressions to be used with different fuels in order to attain the best results.

While on a recent visit to a number of gas- and oil-engine manufactures in the Middle West the writer was impressed by the differences of opinion concerning the influence of compression and the heat value of the fuel upon the power, efficiency and reliable working of the engine. Hence it may be well to discuss these factors from both a theoretical and a practical standpoint to establish their relation upon a sounder basis.

In the early gas engines of, say, 30 years ago, when the only fuel considered was illuminating, or coal, gas and the sizes ranged from 3 to 8 hp., the manufacturer was concerned chiefly with the easy starting and reliable working of the engine as soon as it was in the hands of the user. The writer recalls having been at that time among the first experimenters to employ an indicator on a gas engine.

Some Early Attempts with Compression

The Belgian "Fetu," the German "Benz & Koerting" and some other makes showed a compression varying from 35 to 40 lb. per sq.in. Some years later (about 1890) a few larger engines were put in service, and then arose the need for economy—that is, for a better and more complete consumption of the fuel.

Some successful attempts were made by Otto & Langen, by Benz and by Crossley in producing motors of 10 to 15 hp. and above, with compressions varying from 45 to 60 lb. and a consumption of illuminating gas as low as 25 cu.ft. per b.hp.-hr., which, compared with the 40 or 50 cu.ft. of some years previous, was considered to be a great advance. The corresponding mean effective pressure on the piston was then about 40 to 50 lb. and the initial explosive pressure as high as 250 lb. The better utilization of the gas had led to a slight increase in the useful effect, or the mean explosive pressure upon the piston, although the mechanical efficiency was still very low.

With the exception of the Lenoir engine, which was provided with an electric-spark ignition, practically all the regular makes had ignition devices consisting of a "moving flame" combined with the slide valve that admitted the gaseous mixture and took care of the exhaust gases. This slide valve was held against the ports by springs and would not have complied with higher compression. It was only about 1890, when the first engines with valves of the mushroom type appeared, that higher compressions were realized and the flat slide valve for inlet, exhaust and ignition was abandoned.

The moving flame for ignition was replaced by the incandescent tube, and it may be stated that real progress started with these features, because the mushroom valves, which are gas-tight by themselves, and the ignition hot tube, making no outside communication, were the only means of affording higher compressions, with accompanying increase in initial explosive pressure as well as in the mean effective pressure to a certain extent.

With illuminating gas, which was almost the only fuel in practical use from 1890 to 1900, the compression was carried to 60 or 80 lb. and the mean effective pressures reached 75 to 90 lb. and above. This made possible the building of engines of greater outputs, which was accompanied by new considerations of economy, so as to enable the gas engine to compete with the steam engine. The best consumptions recorded during this period were around 17 to 15 cu.ft. of illuminating gas per brake horsepower-hour, of a calorific value of 600 B.t.u. per cu.ft. which resulted in thermal efficiencies of 25 to 28 per cent.

Manufacturers realized that a further increase of the compression would still improve the consumption, but with the old design of engines having insufficient water-cooling of the cylinders and inside projecting parts liable to become very hot, they experienced drawbacks in the form of severe backfiring and cracking of the castings. For these reasons many English manufacturers for a long period stuck to compressions of 70 to 85 lb.

Then came the suction-producer gas which rapidly grew in favor and was made popular by Continental engineers. This gas, having a low calorific value (between 130 and 140 B.t.u.) and a low percentage of hydrogen, proved rather hard to ignite under average compression, and it was immediately realized that the trouble could be cured by raising the compression from 75 or 90 lb. to 140 or even 170 lb. Thorough water cooling, well-timed electric ignition and sound design of cylinder heads with respect to well-distributed, even strains in the metal, allowed the largest engines to deal with these higher compressions without failure.

Higher Compression with Blast-Furnace Gas

Poorer gases, such as blast-furnace gas ranging from 90 to 110 B.t.u. per cu.ft., which would not burn under normal conditions, are even submitted to compressions of 200 to 220 lb., under which conditions, other things being equal, they are no more liable to preignition than illuminating gas at 80 to 100 lb., as the former yields from 3 to 5 per cent. hydrogen against 48 to 52 per cent. in standard illuminating gas obtained from the distillation of bituminous coal, but without the addition of oil gas, as is often done.

The possibility of higher compressions having been demonstrated when dealing with properly designed combustion chambers, the makers of regular illuminating gas engines applied the experience to their product. After having improved the water cooling, fitted the right kind of ignition and adopted a proper ratio of gas and air in the mixture, they found it most successful as they were enabled to deal with leaner mixtures and increase the

thermal efficiency appreciably without prejudice to the smooth and silent working of the engine.

After having rapidly reviewed the results obtained by an increase of compression, it is useful to examine the reason why higher compression improves the working of the engine, its possibilities and limitations. It should be borne in mind that the principal factors of a quick and complete combustion, as aimed for economy in internal-combustion engines, are: A high temperature of the mixture; an intimate mixing of the fuel, either gaseous or liquid, with the surrounding air; and the proper proportion of fuel to air.

The practical difficulty in securing exactly the theoretical amount of air for burning completely every constituent of the fuel makes it necessary to supply about 1.5 to 2 times the air theoretically required. Atmospheric air contains, by volume, 79 per cent. nitrogen, unavailable for combustion, and 21 per cent. oxygen, which enters into the process of combustion.

Normal illuminating (coal) gas has, roughly, the following chemical composition with the corresponding theoretical amount of air required for combustion by each constituent:

	Per Cent.	Air for Combustion Ratio	Air for Combustion Total
Hydrogen	52	2.38	1.21
Methane	32	9.60	3.3
Ethylene	5	14.60	0.73
Carbon monoxide	7	2.38	0.17
Carbon dioxide and nitrogen (incombustible)	4	.....	....
			5.31

From this we deduce that for burning one volume of the gas under consideration, 5.31 volumes of air are theoretically required; while, as mentioned, from 8 to 11 volumes are necessary in practice in the engine.

These figures will help one to realize the difficulty encountered in effecting an intimate mixture of the gas and air in the very short time afforded in the engine; for the fluids, either gaseous or liquid, must be considered as composed of an infinite number of particles each of which, for the sake of perfect combustion, should be enveloped with the proper quantity of air particles.

It will be readily understood that the higher the mixture of gas and oil is compressed—that is, the smaller the volume it is reduced to—the more intimate and the closer together will be the fuel and the air particles, to the benefit of combustion and economy. Also, the higher the compression the higher the temperature produced by the work of compression: this aids swift ignition and propagation of the flame throughout the explosive mixture in the cylinder.

Besides the theoretical explanations for the increase of efficiency accompanying increased compression, the following figures derived from actual laboratory experiments should be borne in mind. A normal quality of coal gas mixed with the theoretical volume of air, when exploded by ignition in a closed vessel, has given about the following pressures corresponding to the initial compression:

Compression	Explosive Pressure
7.2 lb. per sq.in.	47 lb. per sq.in.
14.5 lb. per sq.in.	112 lb. per sq.in.
35.0 lb. per sq.in.	270 lb. per sq.in.
45.0 lb. per sq.in.	348 lb. per sq.in.

Lack of comprehension of these facts has caused many failures, as some of the earlier builders tried to raise the compression without changing the air and gas valves for making the mixture leaner. The result was excessive explosive pressures with abnormal heat developed in the metal and subsequent cracks in the castings or ruptures of connecting-rods and crankshafts. Instead of improved efficiency the too-hot combustion chambers expanding the incoming mixture diluted it to such an extent that the amount admitted was considerably reduced, while the sharp explosion occurring too early at the dead center allowed an abnormal amount of heat to be carried away through the walls of the combustion chamber, to the detriment of the expanding gases and to the heat to be converted into power.

Besides chemical and physical reasons that have been pointed out in connection with economy due to compression, there is another reason, which may be called of a mechanical nature; this is the detrimental effect of the presence of burnt gases in a fresh explosive mixture, which has led to scavenging the cylinders of the products of combustion before a new charge is admitted. In engines of the two-stroke-cycle type this scavenging is mechanically effected by forcing fresh air through the cylinder previous to the admission of the charge, while in four-stroke-cycle engines it has been endeavored to take advantage of the inertia of the exhaust gases when escaping during the exhaust stroke, to withdraw air through the combustion chamber before the incoming fuel is mixed with it.

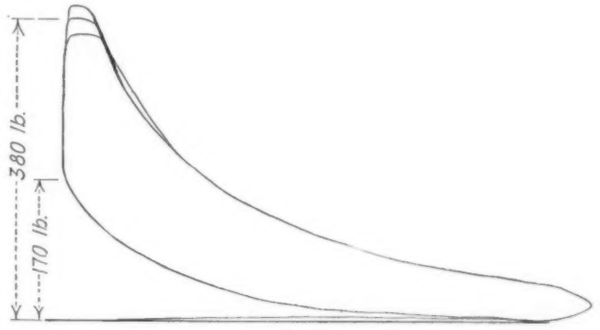


FIG. 1

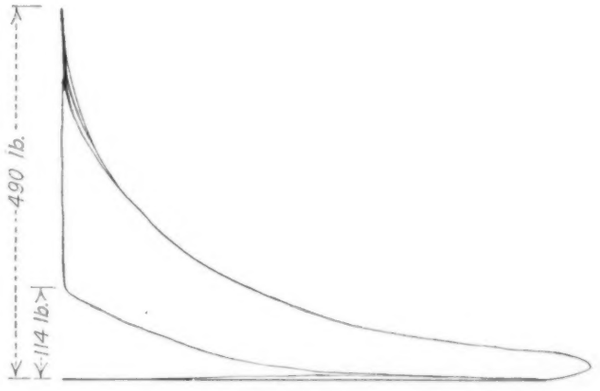


FIG. 2

FIGS. 1 AND 2. SHOWING RESPECTIVELY DIAGRAMS WITH A SLOW-BURNING AND A RICH MIXTURE

If one considers the compression used in gasoline engines, say 70 lb., and that of a modern producer-gas engine, about 170 lb., it will be noticed that the ratio between the clearance volume and the volume generated by the displacement of the piston in each case is: For a compression of 70 lb., 0.45, and for a compression of 170 lb., 0.2. This means that in the second case the content

of the combustion chamber at the end of the inner piston stroke is less than one-half that in the first case; that is, less than one-half of the remaining burnt gases will mix with the fresh incoming charge.

High compressions allow of dealing with leaner mixtures, with the certainty of securing their ignition and thorough burning. In some internal-combustion engines which the writer has studied for European manufacturers and which are known to hold the record of economical consumption, he has even succeeded in making the mixture so lean that, instead of exploding suddenly with a high pressure, it burns slowly and gives an indicator card, as shown in Fig. 1, with a slightly horizontal line instead of the sharp point shown in cards from low-compression engines fed with rich mixtures, as in Fig. 2. The former method leads to smooth working without detrimental shocks on the working parts, at the same time producing a high mean effective pressure, say 75 to 85 lb., with producer gas.

The recommended proportions by volume of air to gaseous fuels at atmospheric pressure are: 1 part illuminating gas, 9 to 11 parts air; 1 part coke-oven gas, 6 to 8 parts air; 1 part producer gas, 1.3 to 1.5 parts air; 1 part blast-furnace gas, 0.9 to 1 part air; 260 to 320 cu.ft. of air to 1 lb. of distillate or heavy oil.

The accompanying table gives the average compressions to be employed and the mean effective pressures realized with different fuels. The figures are derived from actual practice covering over 600 tests which the writer has been called upon to make on about 40 different makes of internal-combustion engines in Europe and America, within the last 25 yr.

ENGINES IN WHICH THE EXPLOSIVE MIXTURE IS COMPRESSED

Kind of Fuel	B.t.u. (high),	Compression, Lb. per Sq.In.	M.E.P. Lb. per Sq.In.
Blast-furnace gas	100 per cu.ft.	170–200	70
Producer gas	135 per cu.ft.	140–170	75
Natural gas	900 per cu.ft.	140–150	90
Coke-oven gas	550 per cu.ft.	120–130	80
Illuminating gas (coal gas)	650 per cu.ft.	110–140	85
Refined petroleum (kerosene)	20,000 per lb.	40–70	60
Refined petroleum with water injection		70–85	65
Spirit or benzol (industrial engine)	17,000 per lb.	70–85	70
Spirit or benzol (automobile engine)		85–100	90
Alcohol or benzol (industrial engine)	13,000 per lb.	100–130	85
Alcohol or benzol (automobile engine)		110–160	95

ENGINES IN WHICH PRIMARY AIR ALONE IS COMPRESSED

Crude oil, Diesel engines	18,500 per cu.ft.	500	105
Crude oil, two-stroke-cycle, hot-bulb engines		140–160	45
Crude oil, four-stroke-cycle, hot-bulb engines		260–300	75
Tar oil, Diesel engines	18,000 per cu.ft.	600	100

The mean effective pressures, given in the table, are maximum figures obtained in well-designed engines and under good working conditions afford an overload, or margin of power, of 10 to 15 per cent.

When dealing with explosive mixtures compressed previous to ignition, it will be noticed that the highest compression pressures are used in connection with blast-furnace gas, while the lowest are those used with gaseous fuels containing a high proportion of hydrogen and therefore liable to preignition due to the temperature caused by the compression itself. This drawback constitutes, as a matter of fact, the actual limitation for high compression. Of course, when dealing with engines of the Diesel or of the hot-bulb type, in which air alone is compressed previous to the introduction of the fuel, there is practically no limitation to the compression unless it be some functional or constructional difficulties caused by the very high temperatures involved. In a Diesel engine the temperature of the air at the end of the compression stroke, although surrounded with water-cooled walls, is about 1,100 deg. F., which causes the burning of the oil as soon as injected.

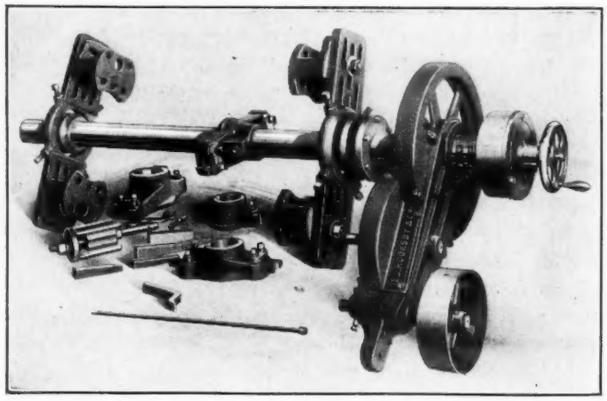
Attention should be called to another fact clearly derived from the table; that is, the absence of any relation between the calorific value of the fuel used and the mean effective pressure. Taking for example the gaseous fuels only, it will be seen that blast-furnace gas with its low calorific value when compared with illuminating gas yielding over six times as much heat, instead of developing one-sixth the power, delivers only 10 to 15 per cent. less.

Within certain limits, in a well-designed engine of the constant-volume type with properly proportioned valves, the power developed is independent of the heat value of the fuel used, but is dependent on the heat value of the mixture introduced in the cylinder. Dealing, for example, with an engine of a given volumetric piston displacement, it will be found that mixing air with blast-furnace gas in the proportion of 1:1 or with illuminating gas at 10:1, the mixtures will be respectively $100 \div 2 = 50$ B.t.u. and $650 \div 11 = 59$ B.t.u. per cu. ft. and give proportional mean effective pressures—that is, proportional power.

To avoid misunderstanding regarding the influence of compression, it may be stated that within certain limits the amount of compression does not affect the power developed; for gaseous fluids these limits are practically between 60 or 75 lb. and 180 or 200 lb. Below the first figures combustion may be imperfect, and above the last trouble may occur owing to excessive heat. As already stated, the compression therefore affects merely the economy, but not the power output.

Cylinder Boring Bar

In the construction of the portable boring bar shown, designed for reboring engine cylinders and valve-chamber bushings, special attention has been given to the safeguarding of all gears and moving parts.



VALVE SEAT AND CYLINDER BORING BAR

The tool can be used with one or both cylinder heads removed. The crosshead blocks are bolted to the cylinder with the cylinder-head studs, and the bar revolves in the sleeves, supported and centered by setscrews in the crossheads. When boring with only one head removed, the expanding chuck and pin, having five sets of taper gibs to fit in stuffing-boxes of various diameters, are used to support the crank end of the bar.

The power is applied to the bar through a back-geared driving power having a two-speed quick-change gear drive. This form of drive is calculated to be of particular advantage where the same bar is used to rebore cylinders and valve-chamber bushings of various sizes. The quick-change is accomplished by simply pulling out a slip pin, shifting the primary pinion out of gear and driving by the intermediate shaft.

The cutter head is fed through an automatic feed case having two changes of feed controlled by a slip pin. For setting the bar up in valve-chamber bushings, a novel device is used, enabling the operation to be quickly and accurately performed. This consists of a set of taper cone sleeves in halves, fitting in the counterbore, supporting the bar central while bolting up the blocks and crossheads, after which the cones are removed and the bar is ready for reboring. The sleeves being taper, one set can be used in bushings of various sizes.

This portable boring bar is manufactured by E. J. Rooksby & Co., Philadelphia, Penn.

Power-Plant Losses at High Altitudes

By A. Vincent Clarke

The pressure of the atmosphere at sea level is 14.7 lb. per sq.in. At lower depths it is increased, and at higher elevations it is less. This reduction of the atmospheric pressure at high altitudes must be taken into account before power plants are installed in such places.

With steam plants the boilers cannot generate as much steam as it is possible to do at sea level, for owing to the rarity of the atmosphere the same volume of air contains a smaller weight of oxygen, and for the same velocity of air through the grates and flues a much slower rate of combustion is obtained.

Considering the engine alone, the working at the high elevation is beneficial because, owing to the reduction of the back pressure, the same quantity of steam at the same pressure as at sea level will develop greater power than can be obtained at sea level. With noncondensing engines this is most apparent, for at an altitude of 10,000 ft. above sea level the reduction in the back pressure is equivalent to the addition of nearly three pounds to the mean effective pressure on the low-pressure piston.

To obtain the same evaporation from a boiler at a high altitude as can be obtained at sea level, it is necessary to use forced draft, but the employment of this might increase the velocity of the air and gases through the grate and flues to such an extent that the operation of the boiler would become uneconomical and it would be better to have a larger one.

Oil engines working at high altitudes cannot develop the same power as at sea level, owing to the smaller weight of oxygen contained in the cylinder. The amount of fuel oil that can be consumed, assuming perfect combustion, is in proportion to the quantity of oxygen present in the cylinder, and because the piston displacement is unalterable, the weight of oxygen in both cases will be in a ratio to the densities of the atmosphere.

The atmospheric pressure at various altitudes is given in the chart, Fig. 1. At an elevation of 10,000 ft. the pressure of the atmosphere is about 10.3 lb. per sq.in. Thus at this altitude the engine cylinder will, at the commencement of compression, be full of air at a pressure of 10.3 lb., whereas at sea level the same volume of air would be present at a pressure of 14.7 lb. The amount of oxygen would be in the same proportion in both cases, so that the power obtainable would be in the ratio of 14.7 to 10.3, giving a loss of about 29 per cent. at the high altitude.

With internal-combustion engine plants intended for working high above the sea level, the lower pressure of the atmosphere will also affect the working of the engine by reducing the compression pressure unless provision has been made for overcoming this. The absolute pressure obtained at the end of the compression stroke, if there is no leakage past the valves and piston, is equal to

$$p_1 \times \left(\frac{V}{v}\right)^{1.35}$$

where

p_1 = Absolute pressure at the commencement of the stroke;

V = Total volume—that is, the piston displacement + clearance;

v = Clearance volume.

From this it is seen that if the initial pressure is reduced, then the compression pressure will be lower, and as the satisfactory running of the engine depends upon the maintenance of approximately the compression for which it was designed, it follows that either p_1 must be increased by artificial means or the ratio $\frac{V}{v}$ must be increased. In practice the latter method is adopted and is effected by either lengthening the connecting-rod or making a new combustion chamber having a smaller capacity; thus the compression pressure becomes the same as that obtained at sea level, but the volume of air is less, consequently the same amount of fuel cannot be consumed and the power is reduced.

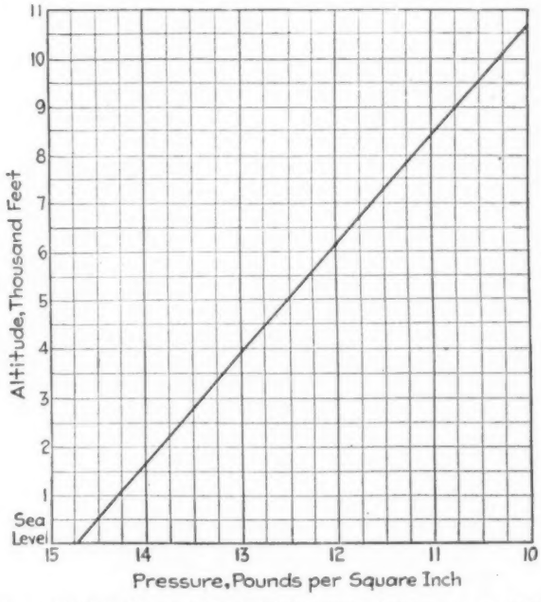


FIG. 1. CHART OF ATMOSPHERIC PRESSURE AT VARIOUS ALTITUDES

Were it practicable to increase the initial pressure in the cylinder to that obtained at sea level, there would be no loss of power at the high altitudes; this result, however, could be obtained only at the expense of the

simplicity of the plant, and in addition to the cost of the extra gear, there would be a certain amount of power required for operating it.

For suction-gas plants a larger producer than is required at sea level would be necessary, and it would

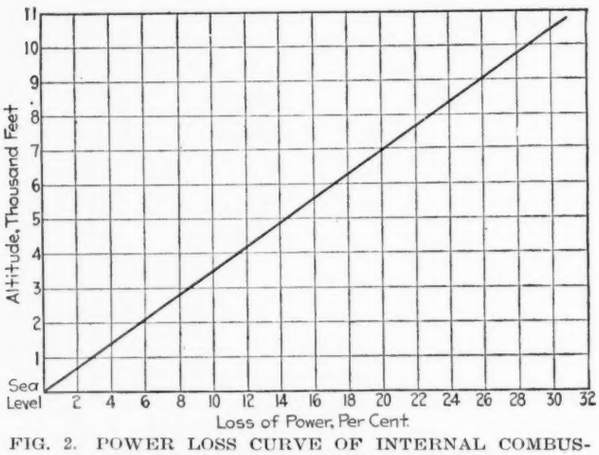


FIG. 2. POWER LOSS CURVE OF INTERNAL COMBUSTION ENGINES AT VARIOUS ALTITUDES

be problematical whether it did not become a pressure producer after the apparatus for producing the draft and the pressure regulator had been added.

The fuel consumption at high altitudes will be approximately the same as would be obtained when working at the same power at sea level; thus the amount of fuel used by an engine at an elevation of 10,000 ft. when working at its full load will be about the same as would be consumed at two-thirds of its full-load rating at sea level.

Diesel engines require a larger compressor for the air used for the injection of fuel when working at a high altitude than is necessary at sea level, as it is essential for their satisfactory operation to have the same volume and pressure of air as at sea level.

The loss of power that occurs with internal-combustion engines at various altitudes is shown in Fig. 2, and as the atmospheric pressure can practically be represented by the straight line shown in Fig. 1, it is apparent that the loss of power can also be represented by a straight line.

Crosshead-Type Diesel Engine

At a recent meeting of the Diesel Engine Users' Association (British), Charles Day of Mirrlees, Bickerton & Day, Ltd., explained that the principal hindrances to the adoption of a crosshead-type Diesel engine were its extra cost and its increased height as compared with the trunk-piston type. Among its advantages are a greatly reduced risk of piston seizing, since the piston does not need to be so close a fit, when the transverse forces due to the connecting-rod angularity are taken by the crosshead and not by the piston.

He pointed to the fact that piston seizing in the trunk type often results from distortion of the piston caused by irregular sections or by expansion of the piston pins. There is also less risk of piston cracking, and it is possible to give much better support to the center of the piston in the crosshead type than in the trunk type, this part being exposed to the greatest heat and to the maximum stress. There would also be less trouble with the connecting-rod top end, since this bearing in the crosshead type is remote from the heat of the piston. To further insure that the piston rod be kept cool and to prevent any oil vapor rising from the crank chambers to the cylinders or any smoke or dirty oil passing into the crank chamber, a cover is fitted between the cylinder and the crank chamber, this cover being provided with a water-cooled gland, which also prevents transmission of heat to the crosshead.

A further important advantage claimed for the crosshead type of vertical engine is greater economy in lubricating oil, as any carbon or dirty oil is prevented from entering the crank chamber from the cylinders, and the lubricating oil therefore retains its condition longer. The lubricant not being splashed or thrown onto the cylinder walls, is kept much cooler, and none of it being lost through the cylinders, a substantial saving obviously results. The air on its way to the cylinders is arranged first to go underneath the pistons, so that any smoke or gas that has passed the pistons will be thoroughly cleared away and a considerable amount of air cooling will also take place. The water-cooled gland mentioned would have none of the disadvantages of a water-cooled piston, since it does not introduce any additional reciprocating weight and its stationary water joints are not likely to cause trouble. The point which might be raised, that in the crosshead type of engine the reciprocating weights would probably be the greater, could be overcome by careful attention to design, since the piston need not be made so thick and heavy as when of the trunk form.

Bursting Pressure of Fittings

A series of tests, reported by S. M. Chandler in 1905 on screwed fittings taken at random from the stock of a prominent manufacturer and tested to destruction with hydrostatic pressure showed, for the various sizes tested, the results given in the table. Those failing at markedly lower pressures than others of corresponding size were cast thinner on one side for the purpose of the test. These tests confirm the general belief that fittings, generally, do not fail from pressure from within or fluid stress alone, but combined with stresses caused by expansion and contraction, water-hammer, improper support and excessive strain on the threads in making up—one or more in conjunction.

As the fittings tested were intended for only 150 lb. working pressure, the factor of safety was ample when properly used:

STANDARD SCREWED CAST-IRON ELBOWS AND TEES—ULTIMATE TEST PRESSURES

Size	Elbows Lb.	Elbows Lb.	Average Lb.	Average Lb.
2¼	3,500	3,300	3,400	3,400
3	2,400	2,600	2,100	2,500
3½	2,100	1,700	2,400	2,250
4	2,800	2,500	2,500	2,600
4½	2,000	2,600	2,600	2,600
5	2,600	2,500	2,500	2,533
6	2,600	2,200	2,300	2,367
7	1,800	2,100	1,900	1,950
8	1,700	1,600	1,700	1,667
9	1,800	1,800	1,900	1,833
10	1,800	1,700	1,600	1,700
12	1,100	1,200	900	1,150

Size	Tees Lb.	Tees Lb.	Average Lb.	Average Lb.
1¼	3,400	3,300	3,300	3,333
1½	3,400	3,200	2,800	3,300
2	2,500	2,800	2,500	2,600
2½	2,400	2,100	2,500	2,450
3	1,400	1,900	1,800	1,850
3½	1,200	1,500	1,500	1,650
4	1,800	2,100	1,700	1,867
4½	1,100	1,400	1,400	1,400
5	1,700	1,300	1,500	1,600
6	1,400	1,500	1,100	1,450
7	1,400	1,400	1,500	1,433
8	1,200	1,400	1,300	1,350
9	1,300	1,400	1,200	1,300
10	1,100	1,300	1,200	1,200
12	1,100	1,000	1,100	1,067

Burnt Oil May Be Cleaned from the cylinder head of an engine by using strong lye-water, and after it is cleaned paraffin rubbed over the surface will keep it bright.

Editorials

Replying to an Adverse Report

After a consulting engineer has recommended shutting down a plant and purchasing power from a central station, the operating engineer usually has the opportunity to submit a rebuttal report. For many men this is a fearsome task. The average engineer would rather tackle the hardest kind of an emergency repair than prepare a report that he knows will be dissected by a specialist and discredited if possible.

The first thing to remember, however, is that the plant owner wants merely the plain facts and their correct interpretation. He is not paying his local engineer to produce literature, but to do his part in producing power at the lowest cost. Attempts at "fine writing" are thrown away here. A simple page of calculations is often sufficient to expose the fallacies of the outside report or a brief note here and there about the consulting engineer's assumptions may serve the needs. Sometimes the engineer will merely have to register his approval of the report's general method, while disagreeing with the way in which it is applied. Rarely indeed is there any call for literary effort beyond giving the straightforward figures and comments that bear witness to the truth as the operating engineer sees it—figures and comments that will stand the technical test.

A clear and orderly arrangement of material is important, as is the putting down in black and white of all assumptions made, as well as estimates. The report should be full enough to enable it to be checked, or else defended in conference, and the reasons for data selected and the whys and wherefores of figures arbitrarily chosen should be included. The temptation to branch forth into long discussions of minor matters and the giving of too much prominence to some pet theory of the local engineer should be avoided, as either is apt to provoke arguments in which he may be at a disadvantage. Beware of riding hobbies in framing rebuttals.

In a fair workout, the report that most clearly bears evidence of truthfulness and sound reasoning wins regardless of its dress. A few figures on a scrap of paper may give a problem a new and a better solution than that proposed in a more elaborate document. So the operating engineer never need worry if he is sure that his figures are right. Since the split more often comes on the portions of the report that deal with fixed charges, with assumptions of depreciated value, of second-hand sale price, of heating requirements and also of probable load factors, it behooves him to be cautious. Every estimate has some sort of a basis unless it is a mere guess, and too much care cannot be taken to keep that basis within reach. Unless the engineer can give some good reason for thinking that a lower rate of interest, for example, should be charged on the existing plant than the outside man advocates, he will be almost sure to get into hot water. Working out the problem for several interest rates is more to the point, and the same thing might be said about depreciation allowances.

The use of dusty data when fresh information can be secured as to equipment performance is unwise. The local engineer has access to up-to-the-minute readings and is often in a position to make more protracted tests than the outside man. Many times the latter bases his conclusions on tests made with the plant at what might be called subnormal efficiency. This makes a poorer showing than when the equipment is up to "concert pitch." If there is ever a time to find out what economies can be effected by stopping various leaks in plant operation, it is when a station is being judged by its record when handicapped by adverse conditions susceptible to betterment. Never should the operating engineer forget that the central-station power engineer seeking the business of his plant turns every discovered source of inefficient service to account in casting up his estimates of yearly cost. The discovery of these weak spots in station service and their remedy before the plant owner decides to abandon the installation for purchased power is one of the most important things with which the engineer can busy himself, and if more time than seems available is required to put these improvements into effect, let his report so state. Interstation visits among engineers should be utilized to establish and maintain an offensive and defensive alliance against all forms of apparent inefficiency.

The Heating Problem

The engineer in charge of a hotel, business block or large shop building is fully as anxious to make a good showing as the man whose job is to furnish only power and light. Too often his work and his record are obscured by antics of the fresh-air fiend, who upon entering a room that seems uncomfortably warm is erroneously impressed with a notion that the air is foul.

Often a man who cares for the heating apparatus in his own home, and who growls like a dog with a sore ear if anyone leaves a door or window open, will go to his office or to a room in a hotel and finding it a trifle too warm, instead of turning off the steam, will throw windows wide open regardless of economy or of the fellow who is shoveling coal in the cellar.

In a way this eagerness to open windows rather than turn off the steam denotes a healthy respect for the engineer's ability to supply all the heat needed, but it cuts quite a figure in coal economy. With the thermometer around the zero mark, fresh air admitted to a room in this fashion becomes an expensive luxury and the chilling effect on adjacent rooms is likely to upset all calculations. When the fresh-air fiend's brow becomes cooled sufficiently to restore his equilibrium, he closes the window, but soon finds the room too cool for him, and as some time is then required to warm it to a comfortable temperature it is next in order for him to vent his wrath on the management, the engineer and the heating system.

Thermostatic heat regulators reduce such abuses of heating apparatus to a minimum. If a regulator is set for a low room temperature when the room is first occupied

and afterward adjusted to any higher temperature that may be desired, there will be less waste of heat by window opening, more satisfactory warming of a room and no interference with the comfort of occupants of adjoining apartments.

Volunteering Information

It has been well said that only a few men are sufficiently informed on any important subject to be content to listen without expressing an opinion. Only a few have the power to avoid the arguments and misunderstandings that bring about the all too common petty regrets, strifes and annoyances. There is a far-reaching lesson in this for the engineer, situated as he generally is between a superior and a number of subordinates. The question is not a technical one, but it concerns a man's reputation in no small degree.

When shall one volunteer information, opinions or criticism to one's superior? It is not sufficient to say that it depends on the personality of the latter. If any general rule can be given, it may be thus: Information may properly be volunteered if action is desired upon the data presented as a basis, or if it is clear that if anything is withheld the interests of the company or firm are likely to suffer or desirable development be overlooked. The engineer who gets the habit of running to his superior with every little trifle makes a big mistake. It is far better that he should be constantly prepared to meet the inquiries of the man above promptly and accurately than that he should frequently break in upon his superior's time without sufficient cause, no matter how pleasant the relations of the two may be.

An ambitious red-blooded engineer with the courage of his convictions will much prefer to be given all the latitude possible so long as he gets the necessary results, and will keep out of the "boss's" office most of the time unless asked to appear there. It should not be necessary to secure his chief's permission before ordering a new feed-pump piston if one breaks or to get an official O. K. before a given boiler can be removed from service for cleaning and inspection. Self-reliance grows best when nourished by a reasonable independence of the executive in matters of detail. So long as the handling of a situation is within the engineer's powers and general authority, the less one thinks about the next man above the better, assuming that in case of a show-down one can back up his opinions against all comers. The best-paid engineers are more valuable for their judgment than for any other quality, and that judgment cannot be exercised efficiently if every step taken depends on the approval of one's next in command. It is better to go ahead and indicate an engine without telling the "boss" than to drift into his office some morning, before the job is even started, with a tale that dilates upon the importance of making such a simple test frequently or with a hypothetical discussion of what the engineer suspects will be found when the cards are analyzed. Time enough to call a busy man's attention to the results if they show that something exists that needs executive action.

In relations with one's superior nothing counts more than evidence that the engineer has something in reserve in his mind; that he is ready and glad to meet every inquiry, but that he has not emptied his brain of ideas bucket-fashion. At conferences where a number of officials and perhaps outside advisers may be present, the engineer who sits quietly by, furnishing the information and opinions asked for and no more, makes an impression that men without self-control or insight utterly fail to appreciate. Many an engineer owes his subsequent advancement to a position of responsibility in another organization to his demonstration of reserve power when called into a conference where he had the good sense to keep from volunteering opinions, while meeting every point brought to his attention with 100 per cent. efficiency.

Likewise, in handling subordinates, it is well to feel sure that information is needed before unloading one's superior wisdom in too great detail. That such information is required can be discovered by a few well-directed questions. The men below do not need to be told something that they may understand already. What chief engineer has not given some long explanation only to find that his understudy was quite as well posted as he himself? Frankness between an engineer and his subordinates and encouragement of inquiries at all times will do much to gain the results desired. Where a man's efficiency can be increased or a helping hand stretched out by volunteering information, well and good; but the wise power-plant commander never forgets that he also is a learner and that the views of his subordinates are always entitled to consideration, even if they are overruled by the man responsible for the station administration. Team-play in the plant solves more than one class of problems.

Cheerup, Bostonians! Your city may yet complete its high-pressure pumping station.

With steam coal costing nearly eight dollars a ton in middle and northern New England because of high freight rates from Norfolk, Virginia, engineers and owners appreciate what an adequate merchant marine would mean to the cost of steam.

The biggest boost the Boiler Code of the American Society of Mechanical Engineers has yet received was given it the other day when the Industrial Commission of Pennsylvania adopted it.

What kind of perversion can induce an organization like the New York Real Estate Association to maintain a lobbyist in Albany to oppose the adoption of legislation requiring boiler owners to comply with the essentials to safety prescribed by the American Society of Mechanical Engineers?

"It will be our aim to make life in the boiler room more pleasant for the firemen. We wish to relieve them of heavier tasks so that they may have more time to watch the flow meter and other instruments and assure themselves that the plant is operating efficiently," says the Southern Illinois Light and Power Company. But it will be a long while before plant owners generally recognize that heat energy from boilers can be bought more cheaply with mental than with muscular energy.

Those Federal Court decisions published last week, legalizing the delegation of certain legislative powers to competent and responsible professional bodies came as a surprise to many.

Correspondence

Use of Armature Bands

Mr. Fox's article in the Feb. 15 issue gives a very clear statement of the use of armature bands and important details in regard to their application. I find that in some types of direct-current motors of from 10 to 25 hp., armature bands were formerly used, but in the later designs have been eliminated, and the coils are held in place by wedges sliding in grooves over the coil and between the armature teeth. For high-speed motors, however, the leads between the laminations and the commutator are usually wrapped with cord to prevent the centrifugal force from throwing them out of place. It is much more difficult to rewind an armature where the coils are held by wedges than where they are banded, because the coils are, as a rule, a snug fit and must be driven down tight before the wedge can be put in. Sometimes this is difficult, and in trying to force in the wedge the insulation may be damaged. Where bands are used, it is not so necessary to drive the coils down tightly, as the binding wires will draw then down.

In one plant with which I was connected, a great deal of trouble was experienced with these binding wires. The motors were nearly all of the same make and many of them the same size. The principal bad feature about this type of motor was that the air gap was very small—barely more than enough to clear the armature bands and allow for any inequality in the diameter of the armature. The bearings in some cases were babbitt-lined cast-iron shells with ring oilers, and in others solid bronze without babbitt. Many of them were located in isolated places or operated by common laborers, but were visited once or twice a day by the millwright helper. He was instructed to test the air gap by inserting a piece of $\frac{1}{32}$-in. fiber between the armature and polepieces. In some cases the average clearance was not over $\frac{1}{16}$ in., and when it got down to $\frac{1}{32}$ in., new bearings were put in. Sometimes, owing to dirt, lack of oil or other causes, the bearing would become badly cut, letting the armature down onto the polepieces, breaking the bands and allowing the coils to catch on the polepieces, with the result that the armature usually had to be rewound.

In installing future motors, the same make was purchased, but instead of having the armatures banded, the wedge type was used. With these, if the armature got down on the polepieces, the additional friction, if not noticed at once, would increase the load enough to trip the breaker or blow the fuse before any serious damage was done.

Another idea we found advantageous in keeping the 80 or more motors in operation was to have a supply of spare bearing shells and armatures, as well as a few extra starting rheostats.

Where the trouble is simply due to worn bearings or an open coil in the armature or other minor defect, it can usually be repaired without disassembling the motor. If, however, the motors are not of the same make or type, as far as possible a much greater investment in spare parts, some of which may seldom be used, is required. Armatures usually give considerable trouble around steel mills, particles of scale penetrating the insulation of the coils and causing grounds or short-circuits. When one coil becomes short-circuited and burns out, it can usually be bridged by putting a jumper across the commutator bars, bridging the open coil; but after three or four coils are bridged in this manner the speed will increase and there will be considerable sparking and it becomes necessary to put in new coils. As a rule, after the old coils have been in use some time, the insulation becomes charred, and when moved to put in a new coil in place of a defective one, the insulation on the remaining coils will be damaged, making it necessary to renew them all.

J. C. Hawkins.

Hyattsville, Md.

Value of Cylinder Oils

Referring to the articles on cylinder lubrication, by James Baudino in the issue of Feb. 8, and by R. E. Edwards in the issue of Feb. 15, I would say that it has been my observation that operating engineers do not give sufficient consideration to the essential properties of a cylinder lubricant, the actual work it is to perform, where it is to perform it and the conditions under which it is to lubricate. And yet it is all so simple.

In the lubrication of an ordinary bearing you apply the oil directly to the bearing. If too much is applied there is usually a method by which the surplus is caught, cleansed and re-used. So there is little extravagance and, as a matter of fact, usually a considerable amount of economy in feeding the maximum quantity of lubricating oil to an ordinary bearing.

With the interior parts of a steam engine it is different. The oil is fed into the main steam pipe. It immediately blends and diffuses with the steam. Only such steam as actually comes into contact with the lubricated parts can possibly convey lubricant that will be useful. All of the other goes out the exhaust as waste. The length of time the lubricant, blended with the steam, is in actual contact with the lubricated parts is a fraction of a second, and the most essential qualification in a cylinder lubricant is the possession of that property which will enable it to best adhere to the lubricated parts, which means that property which will enable the oil to adhere to wet metal surfaces at high temperatures.

This property of adhering to wet surfaces at high temperatures is the only one worth considering; and yet the buyers of cylinder oils, in endeavoring to protect themselves by specifications, never treat of this subject at all.

The fire test amounts to nothing, and no person can give a real argument as to the value of the fire test applied to a cylinder lubricant. If the test was so low that the oil would ignite at atmospheric temperatures, it would not prove that it was a poor lubricant, because

the cylinder oil does not have the advantage of atmosphere in the cylinders.

Viscosity is the great humbug test featured in all specifications, and I should be delighted to debate in *Power*, for the benefit of science, the advantages or disadvantages of a viscosity test as applied to cylinder oils. It means absolutely nothing and proves nothing to the consumer so far as the final quality of a cylinder oil is concerned.

CHARLES E. CARPENTER,
President, E. F. Houghton & Co.
Philadelphia, Penn.

Heat Maladies of Marine Diesels

The article on "Heat Maladies of Marine Diesels," by R. W. Crowly, in the Feb. 22 issue, brings out some good points for the designer, but the conclusions drawn as to the two- versus the four-stroke-cycle engines is challenged.

While it is true that the two-stroke cycle tends to magnify thermal troubles, the heat flow through the cylinder walls is by no means in direct proportion to the greater number of power impulses. A careful analysis of the temperature relations existing in the cylinders of two- and four-stroke-cycle Diesel engines, as presented in "Present Position of Diesel Engines for Marine Purposes," by J. T. Milton, ("Trans. Inst. of Naval Architects," 1914) shows the average temperature in the two-stroke-cycle Diesel engine to be approximately 1,113 deg. F., as compared to 896 deg. in the four-stroke-cycle engine running at the same speed, the temperature ratio being about 1¼.

An important point in favor of the two-stroke-cycle engine is the possibility of dispensing with the inlet and exhaust valves in the cylinder-head casting. I refer particularly to engines in which the scavenging air is introduced through piston-controlled ports in the cylinder walls, in the manner of the new Sulzer engines. The elimination of these relatively large cylinder openings allows of a much more favorable distribution of the head metal; hence the extra heat flow can be taken care of without involving any considerable increase in the total temperature gradient over that produced in the head parts of a four-stroke-cycle engine. This is evident from the fact that the limiting rotative speed in the two-stroke-cycle oil engine is just about on a par with the four-stroke-cycle.

The statement that the two-stroke-cycle oil engine has proved generally unsatisfactory for marine service is not borne out by the large mass of contrary evidence presented in recent technical literature. After some years of experimentation with both four- and two-stroke-cycle engines, a number of leading firms such as Krupp, Schneider-Carels, Sulzer and others now confine their efforts to the building of large two-stroke-cycle machines.

Relative to the merits of two-stroke-cycle oil engines for heavy-duty marine work, the comments presented by W. V. Batho, in discussing the paper previously referred to, are to the point. The following abstract of his remarks relates to the experience gained with Sulzer-Diesel oil engines for marine purposes.

The difference in efficiency between two- and four-stroke-cycle engines is not very great. The following test figures relate to a two-stroke-cycle engine of normal output of 1,500 b.hp. and a four-stroke-cycle unit of 800 b.hp., both having the same cylinder dimensions and running at 150 r.p.m.:

Fuel consumption for two-stroke-cycle engine, 0.31 lb. per i.hp., or 0.44 lb. per b.hp.

Fuel consumption for four-stroke-cycle engine, 0.32 lb. per i.hp., or 0.40 lb. per b.hp.

Some figures of the working of the "Monte Penedo's" engines will, I think, prove interesting. This vessel, which is 4,000 tons gross register and 6,500 tons dead-weight conveying capacity, is engined with two four-cylinder single-acting two-stroke-cycle engines of 850 b.hp. each, running at 140 r.p.m. During the second round voyage, made without mishaps of any kind, the actual working time of the engine was 61 days, 4½ hours; distance traveled, 13,707 mi.; average i.hp. of the two engines, 1,990; average speed, 9.33 knots; fuel consumption including all auxiliaries, 7.2 tons in 24 hr.; lubricating machine oil, 29½ gal. in 24 hr.; cylinder oil, 5½ gal. in 24 hr. The ship left Hamburg on her maiden trip in August, 1912, and up to Sept. 21, 1913, covered, in round figures about 50,000 mi. The only alteration to the engines that have been found necessary were those to the pistons, which was merely a question of improvement in design. Beyond this no repairs other than ordinary have been required.

I should like to add that in the "Monte Penedo's" engines the mean indicated pressure is as high as 110 lb. per sq.in. I mention this because in previous discussions on Diesel marine engines, the statement has been made that builders of two-stroke-cycle engines have been obliged to reduce the mean pressure in the cylinders.

As regards Mr. Crowly's statement that no repeat orders have ever been given for two-stroke-cycle oil engines, this does not appear to square with facts. A full report of the motor ships built is not at present available, but repeat orders are to be found in the guise of sister ships, of which there are a number, and especially in ships having engines of substantially similar design. Among these may be mentioned the Krupp engines in the "Hagen" and the "Loki" and the Carels engines in the "Wotan" and the "France."

That trouble should have been met with in a new line of engines for a new kind of service was to be expected, especially since most of the larger ships were fitted out with two-stroke-cycle engines. Larger engines present a series of inherent difficulties of design not met with in the smaller sizes, but these defects are rapidly being overcome with additional experience, and there seems to be no good reason why the perfected two-stroke-cycle engine in reasonably large powers should not fully meet marine requirements.

The two-stroke-cycle machine also offers another important advantage in that it can be made reversible without resorting to a mass of auxiliary levers and cam mechanism.

Taking up the unfavorable comments made as to the endurance test of the high-speed two-stroke-cycle submarine engine versus the slow-speed four-stroke-cycle cargo engine, it is only natural that the later should be able to withstand overload to a far greater extent. Mr. Crowly mistakenly regards this issue as one of the two-stroke- versus the four-stroke-cycle unit, whereas it is one of the high-speed, versus the slow-speed engine.

The problem presented in the submarine engine is a peculiar one, the weight and space being so restricted that the rotative speed and the stress in the working parts must be carried to the limit in order to attain the desired ship speed. The high stresses and bearing pressures used as a basis of construction are a matter of necessity rather than of choice on the part of the designer. Even a minor weight increase is liable to prevent meeting the speed requirements. While some of the earlier submarine engines of both the two- and the four-stroke-cycle types, were run at excessive rotative and piston speeds the tendency of late has been to reduce these speeds for the sake of greater reliability. Had the German submarine

referred to by Mr. Crowly been fitted with four-stroke-cycle engines, it is likely that the result of additional weight would have prevented the submarine from being in running with the cargo boat at all.

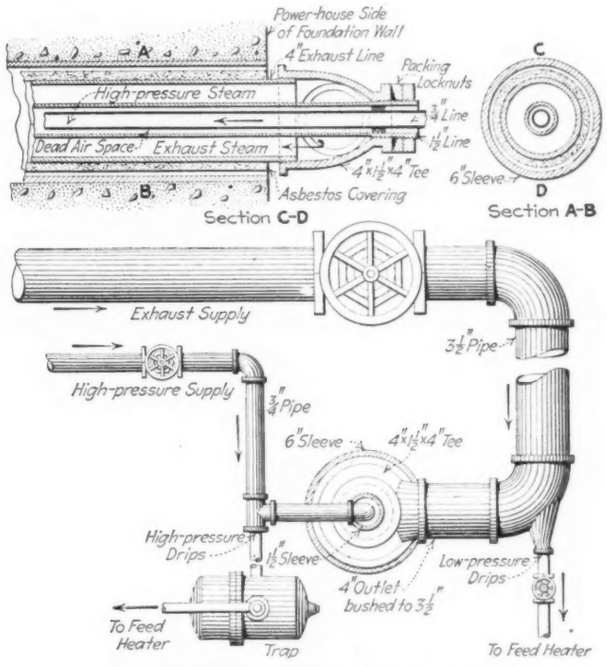
The writer is unaware that the United States Navy has given official expression as regards the merits of the two- vs. the four-stroke-cycle oil engines for ship propulsion. That the navy considers the former favorably is to be concluded from the article in *Power* of Feb. 1, 1916, this being the only large oil engine being built in a navy yard at this time. LOUIS ILLMER.

Bridgeport, Conn.

Novel Steam-Pipe Arrangement

After the erection of a small building it was found necessary to install a ¾-in. pipe carrying steam at 100 lb. pressure for manufacturing purposes and a 3½-in. line supplying exhaust steam for heating from the power plant across a narrow street. It was out of the question to cross above the street, so the job was done in the following manner:

In the 4-ft. foundation walls of the power house there had been provided two openings, the wall having been laid around two sections of 5-in. sewer pipe. One of these



SMALL PIPE WITHIN LARGER ONE

was utilized in carrying the return line from the heating system and wires for power and light.

The other one was enlarged, and the opening was carried through to the basement of the building by boring under the street. A 6-in. pipe, well painted on the outside, was laid and cemented in the two walls to serve as a sleeve and prevent injury to the work. There was not enough room in the 6-in. sleeve to properly cover the 3½- and ¾-in. pipes if placed alongside of each other, so they were put in in the manner illustrated.

Instead of the 3½-in. a 4-in. pipe was used and well insulated with sectional pipe covering. Inside of this a 1½-in. pipe, to act as a sleeve for the ¾-in. line, was placed and centered, and a 4x1½x4-in. tee was made up on each end of the 4-in. pipe. Extra long threads were cut on the 1½-in. pipe to allow room for packing and locknuts, to be used where the 1½-in. sleeve extended through the reduced ends of the tees.

The ¾-in. pipe was then put through the 1½-in. pipe and centered by slipping several iron washers over it, and well packed with asbestos wick around each end, forming a dead-air space around the high-pressure line.

The lines were given enough pitch toward the power house to provide for proper drainage, a steam trap taking care of the high-pressure line, the low-pressure draining into an open feed-water heater below water level.

Philadelphia, Penn. CHARLES M. CREWE.

Sinking Fund in Canadian Municipal Plant

My attention has been called to a misstatement in my paper on the "Municipally Operated Electrical Utilities of Western Canada," abstracted in the issue of Mar. 14. I said that "only depreciation funds to renew the plant are maintained in Winnipeg." This statement misrepresents the practice of the light and power department of that city.

Their policy in this connection is to first apply standard rates of depreciation on the different integral parts of their plant, the average rate approximating 4 per cent. of the total investment. This fund is carried on the books as a "depreciation reserve." From it are deducted the necessary sinking-fund levies, which approximate 1.8 per cent., leaving a balance of approximately 2.2 per cent., which is applied as a "replacement reserve" account. The city therefore maintains sinking funds as well as replacement funds. A. G. CHRISTIE.

Baltimore, Md.

Burning Battery Connectors

I would like to know an inexpensive method of lead burning or soldering to fasten lead connectors to the binding posts of lighting and starting batteries; if possible using material to be found around any small plant.

Glenwood, Minn. C. DICKERSON.

Engine Oil Collector-Filter

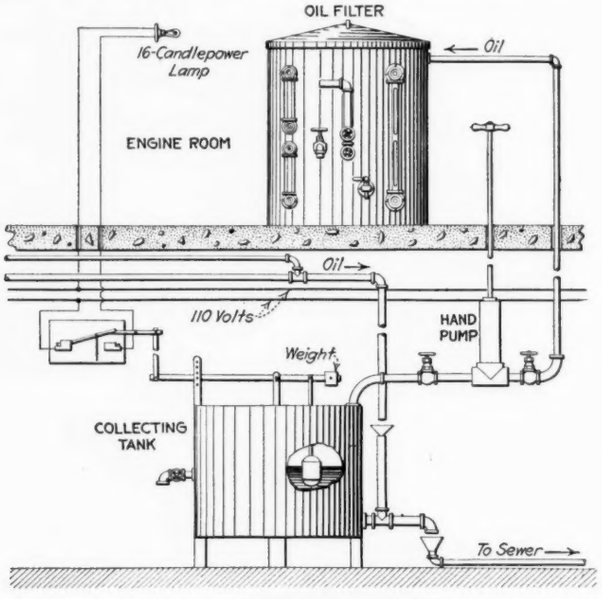
The accompanying sketch illustrates how I handle the oil collected after being used on our engines. The layout is simple and inexpensive, as everything in connection with it can be picked up around a plant, except perhaps the filter. The collecting tank is made if an iron barrel, and the hand pump was constructed out of two check valves and a piece of smooth-bore pipe.

The reason for piping the used oil from the engines to the bottom of the collecting tank is that the tank is kept partly filled with water and the oil in ascending through it is filtered to a certain extent; besides, considerable condensation from the engine is carried to the tank. This arrangement allows the oil to separate from the water.

The oil is then pumped to a filter on the engine-room floor, where it is properly filtered and made ready to use again. As there is some oil lost on the auxiliaries, new oil is occasionally supplied to the filter, which keeps

the whole in good condition. By this arrangement we can afford to lubricate quite generously, and it practically does away with the danger of hot bearings by stinting the oil.

To prevent the collecting tank from overflowing (as it might be forgotten), an electric lamp is arranged to



OIL COLLECTOR AND FILTER

light when the tank is nearly full. The switch is operated by a float and will remain lighted until the tank has been attended to by the oiler. The float is made from a burned-out 100-watt lamp.

After the oil in the collecting tank has been pumped to the filter the switch can be opened and the trip set again. The trip is insulated from the float connections.

Trenton, N. S., Canada. J. A. McGILLIWAY.

Demulsibility Testing of Engine Oils

I believe that the statements in the article on "Demulsibility Testing of Engine Oils," by Frank T. Leilich, in your issue of Feb. 29, are somewhat misleading. At the top of page 295 he says: "The demulsibility is determined by noting the separation of the oil and water, this being expressed in cubic centimeters of separation per hour."

Just above the viscosity curves he says: "Demulsibility tests of *A*, *B* and *C* gave the following results: *A*, 0 +; *B*, 60; *C*, 94." This would seem to indicate that oil *C* came out of emulsion the most rapidly; that is, that it has what might be called the highest coefficient of demulsibility. But as stated at the beginning of the article, highly demulsible oils are the best for the purposes described; and yet oil *C* was the worst of the oils in practice. I can only account for this discrepancy by assuming that the values that the author gives are some sort of reciprocals of the true demulsibility.

I should like confirmation on this point. If my assumption is wrong and the results he mentions are actually measures of the rate of separation of the respective oils and water, the conclusion that demulsible oils are best is evidently diametrically opposite the truth.

San Francisco, Calif. G. O. WILSON.

Uniflow Pumping Engines

We are waiting patiently for the uniflow principle to be adopted by pump builders for small water-works pumps.

We need new pumps. Do you know of anything being done by anyone in this line? There should be great possibilities for efficiency. With old compound-duplex condensing 1½-million pumps we are getting 35 million ft.-lb. duty. The turbo-driven centrifugal will show 70 million. The uniflow crank and flywheel ought to show 70 million at least.

We would like to know all about what the possibilities are before ordering new pumps. WILLIAM A. TRIPP.

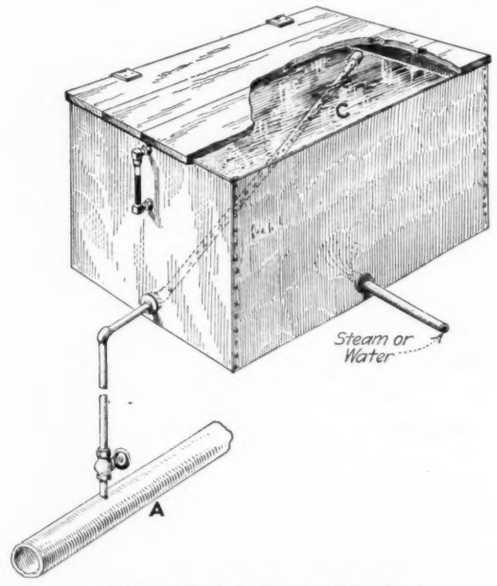
Vineyard Haven, Mass.

Feeder Mixes Compound

The continuous feed is best for putting compound into boilers, and the sketch illustrates one way of doing this successfully.

Many compounds will not stay mixed, and much of the undissolved material will settle to the bottom of the tank. Even with a steam agitator this trouble is not always overcome. The 45-deg. elbow and perforated ⅛-in. pipe *C* capped at the end do much to keep the compound and water mixed as the supply is taken in throughout the whole depth of water; *A* is the suction pipe.

A small water pipe from the discharge side of the pump or a ¼-in. steam pipe may be attached to the other end



TANK FOR BOILER COMPOUND

of the tank to occasionally stir the compound if it settles.

Toronto, Ont. JAMES E. NOBLE.

Repairing a Leaky Cylinder

A cylinder that leaks because of open-grained or porous iron can be made steam-tight in the following manner:

Make a saturated solution of hydrochloric acid (also known as muriatic acid) and iron drillings; pour this solution into the cylinder or wash the interior of the cylinder with it; then apply ammonia water and a pres-

sure of steam or air. This will drive the solution into the pores of the walls, closing them by oxidation. When dry, the cylinder will be steam-tight.

The hydrochloric-acid solution is made like soldering acid except that iron drillings are used instead of zinc.

South Orange, N. J. WILLIAM PHILIP.

To Test for Tight Belts

A good way to determine whether belts are too tight is to try the flywheel test. How long does the engine continue to run after steam is shut off with tight belts, and how long does it run with slack belts?

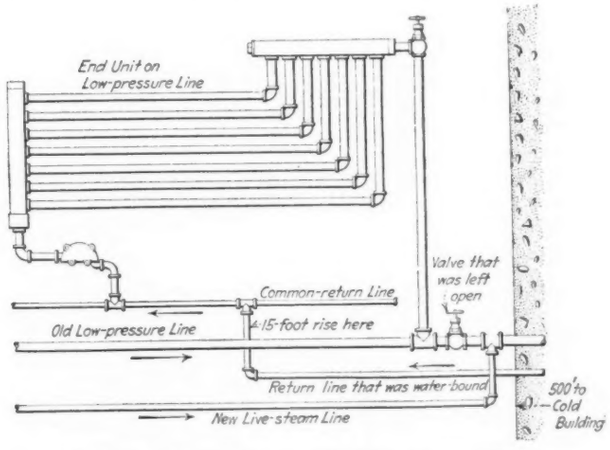
In making this test the engine should not be pulling any load aside from the friction load of belts and shafting. Perhaps it is impossible to run all belts extremely slack for the sake of increasing the stopping time to the maximum, but there is no good reason why they should be run tight. There is a "happy mean" somewhere and the flywheel will tell you more accurately than will an indicator whether the belts are consuming too much power. Make the stopping time as long as possible—the longer the better. The money saved is directly proportional to the increased time. S. F. WILSON.

New York City.

Could Not Heat Building

One bitter-cold night I was called out by the night engineer, who stated that one of the buildings had grown cold and that he had failed to get the heat over there; so I joined him in the effort to ferret out the trouble. The building had always been hard to heat, being so far from the boiler house, and since the vacuum pump was out of order, we were depending on a gravity return.

Originally the supply was from the extreme end of the system in one of the main corridors, but later an independent live-steam line had been run for this building; there was plenty of steam on this line, but not the slightest evidence of it in the building. In installing the special line it had been carried to the end of the corridor of another building and there joined, near the wall, to the old line, which was used for the remainder of the distance. The illustration shows the connection referred to, in the adjacent building. A valve was located in the old line beyond the last heating coil and just back of where the new live-steam line joined the old one. This valve had been opened by someone, so the live steam was entering the low-pressure system, completely short-circuiting the building beyond; besides, there was a trap or pocket in the return line where it connected with the common return of about fifteen feet, and to dislodge the water in this return pipe would probably require a pressure of six or seven pounds. When the valve was closed, the system was soon blown out and the building heated.

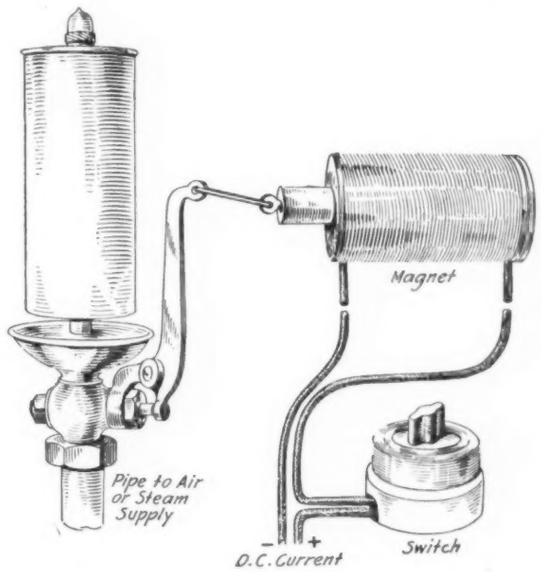


HOW NEW STEAM LINE WAS CONNECTED

Philadelphia, Penn. EDWARD T. BINNS.

Soleonid-Operated Whistle

In a large power plant, it is often necessary to call various employees to the telephone or the office. The old-time practice of sending a messenger in search of the person desired involved delay and expense. I had occasion, some time ago, to develop a call system that would obviate the difficulty.



ELECTROMAGNETICALLY OPERATED WHISTLE

First, a steam whistle operated by a cord was installed, but this proved to be cumbersome, partly on account of the amount of bell cord necessary to operate it from the office. Later, I secured a spare coil used for operating the pilot valve on the old-type Curtis turbine and a piece of iron pipe about 6 in. long threaded on one end for a plunger. To the pipe was screwed a cap previously drilled and tapped to receive a small eye-bolt. To this was attached a piece of fiber the proper length to reach from the eye-bolt in the end of the core to the whistle-valve lever on the end of the air-supply line, and the magnet and core were placed on a board and lagged firmly to the wall.

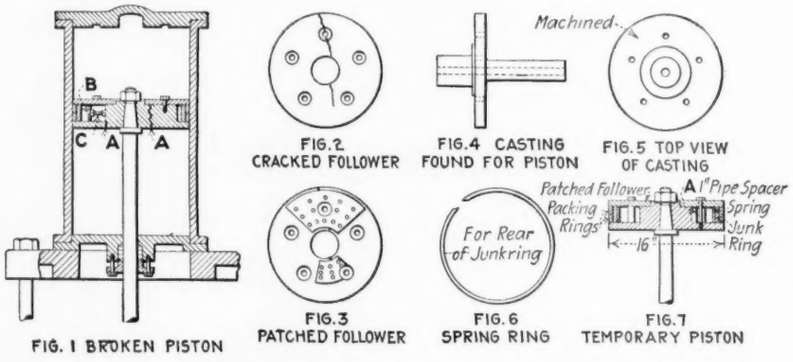
Two leads were run from the direct-current bus to the terminals of the magnet and to the superintendent's office and connected to a snap switch. When current was applied to the magnet, the core was pulled inward, opening the whistle valve, and when the current was cut off, the spring in the whistle valve immediately pulled the core outward, closing the valve. This left the core in position for a second application. This apparatus has been in service and given good results for the last three years.

Lyons, N. Y. WAYNE G. BROOKINS.

An Emergency Steam Piston

The steam piston on a 16x35x21 twin vertical condenser circulating pump in a 4,000-hp. plant broke and was repaired in record time a few years ago.

The plant furnished power to a factory and also a 24-hr. commercial light and power service. The day load was nearly full capacity, the evening load at the time about ⅔ and after midnight about ⅓ the day load, so the engines could not carry the day load when exhausting to the atmosphere, and the pump that failed served the common condenser for all three engines. Early one evening as the load began to drop off, the circulating pump developed signs of distress by groaning and shaking on the upstroke of the left-hand piston, and after a few strokes it stopped dead. It was first found that the steam valves were inoperative, and this led to the discovery of a piece of iron wedged in the port under the main valve of the left-hand cylinder. In the cylinder two of the follower-stud nuts were lying loose on the follower plate and the studs were missing from the holes in the follower. Upon removing the follower a completely wrecked piston was revealed. The stiffening webs had cracked at the hub *AA*, Fig. 1, and also the lower part of the piston itself had developed several radial cracks, so that the piston was broken into three pieces held in place on the upward stroke by the irregularities of the fractures and on the downward stroke by the follower plate and bolts. Then these bolts failed, and nearly half of the piston had fallen to the bottom of the cylinder and the follower plate, Fig. 2, had also cracked.



BUILT-UP PISTON FOR TEMPORARY USE TO REPLACE BROKEN ONE

According to the creed of the engineering craft, that pump must be on the job within ten hour for the day load, but how? The suggestion of a plate patch was abandoned, but on searching in the storehouse to see what might be found that could be utilized, a casting, Figs. 4 and 5 (a large disk having a long hub, designed to be used on one of the machines in the factory), was selected. This was taken to the factory repair shop, the hub cut to a length equal to the depth of the old piston and bored to the taper and size of the piston rod, and the outside of disk turned to a clearance fit in the cylinder; also a part of one side was faced to take the packing rings. It was then drilled and tapped (Fig. 5) to match the follower plate, which had in the meantime been patched with a ¼-in. iron plate (Fig. 3).

After fitting studs into the improvised piston, five pieces of 1-in. pipe *A*, Fig. 7, were cut off square to a length to permit tightening down hard on the follower without pinching the packing rings. These rings were previously set out by springs on the ends of adjusting screws *B* and *C*, Fig. 1, but time did not permit of making similar provision in the temporary piston, so a piece of flat steel wide enough to back up the junk ring was bent to a circle (Fig. 6) larger than the inner diameter of the junk ring and sprung into it. The piston was then bolted together (Fig. 7) and put on the rod, the cylinder head put on and the pump started in good time to take care of the increasing morning load.

The piston worked so well while a new piston was being made and shipped from the factory that when it was finally removed, it was boxed up and stored away to be in readiness should another failure occur.

Maynard, Mass. CHARLES L. WARE.

Jumping of Feed Pumps

In using feed pumps operating engineers are frequently puzzled to find the cause of the irregular motion known as jumping.

If the pump is old and has previously given satisfactory service, the erratic operation may be due to air leakage during the suction stroke of the piston on the erratic side. Air thus admitted, causing slight resistance, permits the piston to jump forward on the discharge stroke until the air is compressed and the volume of water drawn into the cylinder during the suction stroke practically fills the space ahead of the moving piston, causing the piston to again move slowly when discharge pressure is reached.

The air may leak through stuffing-box, bad gaskets, defective castings, drip holes or other openings into the suction chamber on the troublesome side. If the piston jumps only in one direction and that on the stuffing-box side, the difficulty is probably due to faulty stuffing-box packing, which will generally show evidence of leakage on the discharge stroke. One or more of the suction valves may hang up during the part of the discharge stroke through which the piston jumps. This might be due to defective valve springs or valve covers or to rubbing on the walls of the water chamber. The piston rod may be scored so that when the packing is adjusted to keep the leak to a minimum, it pinches at the end of the stroke, or the water cylinder may be scored for part of its length, permitting slippage, hence reducing the resistance ahead of the piston for that part of the stroke.

If the pump is new or has been recently repaired or relined, the erratic operation may be due to several causes. The water cylinder may have been machined tapered or may have been fitted with a lining that became tapered or distorted at one or both ends by the process of forcing it into place; or the steam and water cylinders may not be bored in line.

Ninety-nine out of every one hundred pump troubles may be traced to the water end, and it has always seemed strange to me that a first-rate engineer, priding himself on his engine upkeep and his knowledge of steam, will neglect the heart of his plant—the boiler-feed pump—and give little thought to the principles of hydraulics.

Holyoke, Mass. ROBERT E. NEWCOMB.

Inquiries of General Interest

Engine Efficiency—What is the mechanical efficiency of an engine when its indicated horsepower is 24.37 and its brake horsepower is 21.16? C. W.

The mechanical efficiency of the engine is

$$\frac{21.16}{24.37} = 0.866, \text{ or } 86.6 \text{ per cent.}$$

Buckling of Fire Tubes—What causes tubes of fire-tube boilers to become bent or buckled out of line? J. R.

The buckling may result from relaxation of the stresses that are introduced by bending the tube to straighten it or for the purpose of getting it in the boiler, or may be due to one side of the tube becoming heated more than the other from carrying a low water level or from a deposit of scale on the tube.

Space Occupied by Coal—What space per ton is required for storage of steaming coal? T. B.

The space varies with the size and kind of the coal. Anthracite, nut size, occupies about 34.3 cu.ft. per ton of 2,000 lb.; pea size, about 37.6 cu.ft.; buckwheat, about 37 cu.ft.; and anthracite dust, about 35 cu.ft. Eastern bituminous coals occupy about 43 cu.ft. and Illinois coals about 42.3 cu.ft. per ton of 2,000 lb.

Placing U-Bend in Pipe Line—When a U-bend is used in a pipe line for taking up expansion, how should the bend be placed? N. F.

The bend should be in the same plane as the pipe; that is, it should be so placed that the ends will be forced nearer together or drawn apart by the action of expansion or contraction of the line whose variation in length it is intended to compensate by the flexibility of the bend.

Hit-and-Miss Method of Governing Gas Engines—What is meant by the hit-and-miss method of governing gas engines? F. R. S.

In the hit-and-miss method of governing a gas engine the gas-admission valve is opened regularly by the valve gear during the suction strokes as long as the speed remains normal, and when the speed exceeds normal the governor moves the valve-gear to a position that causes the valve to miss opening.

Feed-Water Temperature with Open Heater—What is the highest temperature obtainable for feed water when heated in an open feedwater heater? M. C.

In an open feed-water heater the water to be heated is under atmospheric pressure and its temperature cannot be raised above 212 deg. F. because, when that temperature is attained, any addition of heat is employed as latent heat of vaporization that converts the water into steam at atmospheric pressure.

Reducing Blowdown of Pop Safety Valve—A spring safety valve that pops at 140 lb. continues to blow until the boiler pressure has been lowered to 130 lb. per sq.in. How can the amount of blowdown be reduced? W. D. G.

Most pop safety valves are provided with an adjustable sleeve, or ring, that causes the escaping steam to react against the valve in such a manner as to assist the pressure of the boiler in holding the valve off its seat. By moving the ring farther away from the valve, there will be less reaction of the escaping steam and the amount of blowdown will be reduced.

To Obtain Given Compression of Exhaust—Having an 18x36-in. noncondensing engine with 5 per cent. clearance, at what point of the back stroke must the exhaust valve be closed for exhaust at 2 lb. back pressure to be compressed to 40 lb. gage? G. E. S.

The volume of the exhaust in the cylinder at 2 lb. gage at the time the exhaust valve closes is equal to the displacement of the piston for the remainder of the stroke, plus the volume of the clearance space into which the exhaust is compressed, and for practical purposes the exhaust may be considered to be compressed isothermally, from 2 + 14.7, or 16.7 lb. absolute, to 40 + 14.7, or 54.7 lb. absolute. If f = the fraction of the stroke uncompleted when the exhaust valve closes, then $(f + 0.05) \times 16.7 = 0.05 \times 54.7$, or $f = 0.1136$ of stroke uncompleted when the exhaust valve would have to be closed; that is, when the piston has completed about $36 \times (1 - 0.1316) = 31.91$ in. of the back stroke.

Filling Spherical Vessel with Condensate—What time will be required for a spherical vessel 14 ft. diameter made of ⅝-in. steel, exposed to an atmosphere of 90 deg. F., to become filled with condensate of dry saturated steam supplied at 60 lb. gage, if the water as it accumulates is agitated so as to keep it at practically the same temperature as the steam? J. W. D.

Under the conditions stated, the steam or water contained by the vessel would have a temperature of 307.6 deg. F. The cooling surface, or area, of the sphere would be 4 times the area of a great circle, or $4 \times (14^2 \times 0.7854) = 615.75$ sq.ft., and the cubic capacity would be $(615.75 \times 14) \div 6 = 1{,}436.75$ cu.ft. Heat would be radiated from the vessel at the rate of about 2.5 B.t.u. $\times$ (307 — 90) = 542.5 B.t.u. per hr. per sq.ft. of surface, and the total loss of heat would amount to $615.75 \times 542.5 = 334{,}044$ B.t.u. per hr. The latent heat of steam at 60 lb. gage, or 75 lb. absolute, is 903.7 B.t.u., and to maintain the temperature of the contents of the vessel would require condensation of $334{,}044 \div 903.7 = 369.6$ lb. of steam per hour. Water at 307 deg. F. weighs 57.23 lb. per cu.ft., hence the time required for the vessel to become filled with condensate would be $(1{,}436.75 \times 57.23) \div 369.6 = 222.47$ hr.

Heat Value of Fuel Elements—What are the heat values of the combustible substances of which fuels are composed? H. C.

The principal fuel elements which generate heat on being burned are carbon (C), hydrogen (H) and sulphur (S). In the process of burning, these fuel elements unite with oxygen of the air supplied and, in doing so, liberate a definite amount of heat, according to the product. The carbon may form one of two substances. If there is sufficient oxygen present and the carbon is brought in contact with it, carbon dioxide (CO_2) will be formed, and this is the product resulting from complete combustion of carbon, since it has united with all the oxygen possible. But if there is not sufficient oxygen present, the compound formed will be carbon monoxide (CO). The hydrogen unites with oxygen and forms water (H_2O), and the sulphur unites with oxygen to form sulphurous acid (SO_2). These chemical combinations of the substances liberate heat as follows:

	B.t.u.
1 lb. of carbon burned to CO_2	14,500
1 lb. of carbon burned to CO	4,400
1 lb. of hydrogen burned to H_2O	62,100
1 lb. of sulphur burned to SO_2	4,000
1 lb. of CO burned to CO_2	4,330

Proximate Analysis of Coal—What is determined by the proximate analysis of coal, and how is it performed? R. J.

Proximate analysis determines the proportions of carbon, volatile matter, moisture and ash. From the coal sample an average sample of about 40 grams is pulverized by passing it through an ordinary coffee mill. It should then be dried in a double-walled air bath kept at about 220 deg. F. and weighed at intervals until a minimum is reached. The percentage of moisture can be calculated from the loss in such a drying. A portion of this dried sample should then be thoroughly pulverized and, unless immediately used, should be placed in an air-tight receptacle. One gram of the pulverized sample should be weighed in a porcelain crucible with a well-fitting lid, and with the crucible supported on a platinum triangle, it should be heated for about seven minutes over the full flame of a Bunsen burner. The crucible and contents should then be placed in a desiccator containing calcium chloride and, when cooled, should be weighed. From the loss the percentage of volatile combustible matter may be calculated.

The same sample from which the volatile matter has been driven should be used in determination of the percentage of ash. This percentage is obtained by burning the fixed carbon over a Bunsen burner or in a muffle furnace. The burning should be continued until a constant weight is secured, and may be assisted by stirring with a platinum rod. The weight of the residue determines the percentage of ash, and the percentage of fixed carbon is calculated from the loss during the determination of the ash after the volatile matter has been driven off.

[Correspondents sending us inquiries should sign their communications with full names and post office addresses. This is necessary to guarantee the good faith of the communications and for the inquiries to receive attention.—Editor.]

New England Power Company Is Prospering

An increase of over 50,000,000 kw-hr. over 1914 is recorded in the annual report of Pres. George S. Smith, of the New England Power Co., Boston, Mass., covering the calendar year 1915. The demand for power on this system, which is one of the largest in the East, appears due not only to the great business activity of the times, but even more to the purchase of electricity from this system by public-utility and manufacturing organizations throughout central New England. The output for 1915 was 173,000,000 kw-hr., excluding the equivalent of 50,000,000 kw.hr. sold at Bellows Falls, Vt., in water power; the gross earnings were $1,489,000, compared with $982,000 in 1914, and the earnings after deducting operating expenses and taxes were $957,899, against $509,741 a year ago.

Last year plant No. 5 on the Deerfield River, operating under a head of 240 ft., went into partial service, and the last generating unit was placed in operation in November. During 1915 the high-tension lines of the affiliated companies were extended from Uxbridge, Mass., through Woonsocket and Pawtucket, to Providence, R. I., connecting with the Stone & Webster Blackstone Valley property and the system of the Narragansett Electric Lighting Co. Contracts aggregating 15,000 hp. have been secured in Rhode Island. In July, 1915, the plant of the National Metal Box Co., on the Deerfield River, at Readsboro, Vt., was acquired. The dam and hydraulic plant have been rebuilt and should be in operation early in April. This plant will add about 12,000,000 kw.-hr. per year to the output of the system and will also give an increased supply of summer power, as the stored waters of the Somerset reservoir will be utilized through the wheels of the new plant. The power company now controls the Deerfield River from Wilmington, Vt., to Shelburne Falls, Mass., a distance of 35 miles. There was a surplus for the year, after dividend payments, of $125,671.

Boiler Explosion Kills Six

The accompanying illustrations show the result of a boiler explosion that occurred at 11:30 a.m., Thursday, Feb. 10, instantly killing four men and fatally injuring two others. The boiler was used at a sawmill situated about 12 mi. from Salisbury, Ind., and was owned by Hurley & Graham. The sawmill machinery was demolished.

The boiler was of the ordinary return-tubular type of about 35 hp. From all appearances it was very old and had at one time been patched with a screw plate on the longitudinal seam just about the water line. The plates were thin

FIG. 2. TUBES AND TUBE SHEETS OF THE BOILER

—in some places not over ¼ in. thick. The main sheets, or shell, Fig. 1, landed about 300 ft. from its brick setting and the flue sheets and tubes, Fig. 2, landed about 150 ft. away. The engine was broken in half, the cylinder and piston being blown about 100 ft. from its foundation.

It is stated that the engine was shut down to get up steam and that when the gage registered 100 lb., the mill again started, followed by the explosion. From the appearance of the shell plate the indications are that the shell ruptured at the longitudinal lap-joint seam and tore from head to head. The shell was then blown from the heads, leaving most of the tubes in the tube sheet. It will be noticed that the left end of the plate, Fig. 1, tore at the rivets; the other end evidently sheared the rivets, as the right tube sheet, Fig. 2, shows that the rivets are missing from the rivet holes, which are intact. The position of the through braces and of the rivets in the head leads to the supposition that the head in the foreground is the front head of the boiler. The indications are that the head is badly bulged, and the appearance of the boiler shell at the head end shows that the initial rupture occurred at the front end of the boiler. The shell shown in Fig. 1 indicates either that the plate is burned at the head end or that it is badly scaled.

The usual cause of low water is given by some as responsible for the explosion, but if the facts are as stated (which it has been impossible to verify) the explosion was more likely caused by operating an old and dangerous boiler at too high a steam pressure.

FIG. 1. SHELL OF THE EXPLODED BOILER THAT WAS BLOWN ABOUT 300 FT.

Massachusetts Boiler Inspection Department Attacked

Representatives of operating steam engineers appeared for and against bills to establish a bureau of steam engineering in Massachusetts at a recent hearing before the committee on mercantile affairs. Representative Weeks, of Chelsea, led the fight in favor of the bill and was supported by Dudley G. Kimball, chairman of the legislative committee of the N. A. S. E., and Arthur M. Huddell, of the Massachusetts state branch of the International Union of Steam and Operating Engineers. Mr. Kimball criticized the department of boiler inspection on the ground that too much time is required at present for even a competent man to obtain a license and contended that the examination requirements should be more uniform. He favored a combined oral and written examination.

Mr. Huddell said that there is no logical reason for placing boiler inspection in the hands of the District Police, as at present. He condemned the board for detailing inspectors for police and strike duty and said that detective work interferes with the true functions of the inspector. There are now 25 inspectors in the department, and he said that steam engineering and all allied safety work should be transferred to an independent department. He criticized the board for the lack of recommendations relative to recent boiler explosions. Closing, he said that there has not been a meeting of the inspectors for two years. William M. Beck, of Boston, also favored the placing of the department on its own feet.

The establishment of a new department was vigorously opposed by Jonathan Perry, of the International Union (Local 16), and P. J. Gorman, president of Stationary Engineers of Greater Boston. Both pointed out that no need of a change exists at present, and the second speaker emphasized the efficiency with which the department is conducted. The license law in Massachusetts is 20 years old and has worked well. J. A. Nash, of Boston, defended the examinations of the board and averred that the plan to transfer the department is largely an attack upon the present head of the department, Deputy-Chief George A. Luck.

C. C. Bletzer, of Boston, said that it would have been much more to the point if the proponents of the bill had brought in legislation directed against the lap-seam boiler. More inspectors are needed to enable the work to be carried on to best advantage. J. H. Henderson, secretary of the New England States Association of Stationary Engineers, contended that to establish the department on an independent basis would not change the methods of examination or administration. Chief Plunkett of the District Police said that only 1 per cent. of the inspectors' time had been taken in police duties. F. H. Boyer, of Somerville, Mass., Lewis Peterson, of Boston, representing boiler-makers, and P. J. Thornton, representing firemen, also opposed the bill. Deputy-Chief Luck opened his records to the committee and said that the facts regarding the examinations court their fullest inquiries, after which the hearing was adjourned.

Boiler Legislation

Thomas E. Durban, chairman of the Administrative Council of the American Uniform Boiler-Law Society, announces under date of Mar. 25 that they have a bill in the New York legislature which they hope will be reported out of committee "this week." This bill is simply an amendment to the labor law requiring that all boilers in use in the state shall conform to the Boiler Code of the American Society of Mechanical Engineers. It has the indorsement of the State Industrial Commission, the Associated Manufacturers and Merchants of New York State and the New York branch of the American Federation of Labor. A committee, consisting of Mark Daly, secretary of the Associated Manufacturers and Merchants; H. G. Stott, of the Interborough Rapid Transit Co., of New York; Isaac Harter, Jr., of the Babcock & Wilcox Co.; E. R. Fish, of the Heine Safety Boiler Co.; Mr. Snyder, of the Lidgerwood Co.; Mr. Cole, of the American Locomotive Works; Mr. Burchfield of the Kingsford Foundry and Machine Works, and the chairman, appeared before the Judiciary Committee. After the hearing all opposition to the bill was withdrawn with the exception of that of the representative of the New York Real Estate Association, which was continued to the end.

In Maryland President Goodnow, of Johns Hopkins University, who is chairman of the Commission of Efficiency, has been interested in the measure, but the report of his commission upon the consolidation of departments and the general efficiency of the state is in the hands of the governor, and it was not considered advisable to introduce any bill until this report, with which the bill must be in harmony, has been made public.

Through the efforts of the society the interest of the governor of Virginia was enlisted, and he recommended in his message to the legislature on Jan. 22 legislation upon steam boilers. A bill was introduced, and a promise for its support from the labor interests secured. Later, however, the labor people introduced a bill of their own, and both bills were killed in committee.

In New Jersey it was found impossible to introduce a bill, because the attorney general decided that the whole code would have to be printed in the act, and neither time nor the remains of the printing appropriation allowed this to be done.

Through the excellent work of E. R. Fish and John Hunter an ordinance has been introduced in the city council of St. Louis, making the A. S. M. E. Code the official specification for that city.

Through the efforts of Joseph J. Nelis, of the Cincinnati office of the Babcock & Wilcox Co. and the Engineers and Architects' Society, the new building code for the City of Nashville, Tenn., specifies the A. S. M. E. Code.

Turbine Accident at Michigan City—A Western correspondent advises that recently a 3,750 kv.-a. 3,600 r.p.m. double-flow turbine exploded (ran away?) in the power house of the Chicago, Lake Shore & South Bend Ry., at Michigan City, Ind. There were no personal injuries.

A Correction—Remington Arms and Ammunition Co.'s Power Plant—In the table of principal equipment accompanying the article on the Remington Arms and Ammunition Co.'s power plant, published on page 315 of the Mar. 7, issue, the following credits should have been given: The venturi meters were made by the Simplex Valve and Meter Co., the boiler feed-water heater by the Hoppes Manufacturing Co., and one of the three 2,500-gal. per min. hot-water heating turbine-driven pumps by the Lea-Courtenay Co., the other two being made by the De Laval Steam Turbine Co. The 8-in. flow meter was made by the Bailey Meter Co.

STATEMENT OF THE OWNERSHIP, MANAGEMENT, ETC., REQUIRED BY THE ACT OF CONGRESS OF AUGUST 24, 1912.

of Power, published weekly at New York, N. Y., for April 1, 1916.

State of New York } ss.
County of New York }

Before me, a Notary Public in and for the State and County aforesaid, personally appeared Chester W. Dibble, who, having been duly sworn according to law, deposes and says that he is the Vice-President of Hill Publishing Co., publisher of Power, and that the following is, to the best of his knowledge and belief, a true statement of the ownership, management, etc., of the aforesaid publication for the date shown in the above caption, required by the Act of August 24, 1912, embodied in section 443, Postal Laws and Regulations, printed on the reverse of this form, to wit:

1. That the names and addresses of the publisher, editor, managing editor, and business manager are:

Publisher, Hill Publishing Company, 10th Ave. at 36th St., New York, N. Y.
Editor, Fred R. Low, 10th Ave. at 36th St., New York, N. Y.
Managing Editor, Henry R. Cobleigh, 10th Ave. at 36th St., New York, N. Y.
Business Manager, William Buxman, 10th Ave. at 36th St., New York, N. Y.

2. That the owners are:

Hill Publishing Company, 10th Ave. at 36th St., New York, N. Y.
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The balance of the stock issued (less than 1% each) is owned by 68 employees, 3 ex-employees, and 13 others who are wives, daughters or relatives of employees.

3. That the known bondholders, mortgagees and other security holders owning or holding 1 per cent. or more of total amount of bonds, mortgages or other securities are: Mortgage on building, Dime Savings Bank, Brooklyn, N. Y.

4. That the two paragraphs next above, giving the names of the owners, stockholders and security holders contain not only the list of stockholders and security holders as they appear upon the books of the company, but also, in cases where the stockholder or security holder appears upon the books of the company as trustee or in any other fiduciary relation, the name of the person or corporation for whom such trustee is acting, is given; also that the said two paragraphs contain statements embracing affiant's full knowledge and belief as to the circumstances and conditions, under which stockholders and security holders who do not appear upon the books of the company as trustees, hold stock and securities in a capacity other than that of a bona fide owner; and this affiant has no reason to believe that any other person, association or corporation has any interest direct or indirect in the said stock, bonds or other securities than as so stated by him.

CHESTER W. DIBBLE.

Sworn to and subscribed before me this 31st day of March, 1916.

[Seal.] RICHARD L. MURPHY.
(My commission expires March 30, 1917.)

New York Section A. S. M. E. Social Dinner

The New York Section of the American Society of Mechanical Engineers, comprising the membership residing in or near New York City, held its first strictly social function Wednesday, Mar. 29, at the Machinery Club, in the shape of an informal dinner followed by dancing. The guests and speakers were F. R. Low, editor of "Power"; Spencer Miller, one of the two representing the Society on the Naval Consulting Board; and Calvin W. Rice, secretary of the society. Edwin J. Prindle, chairman of the entertainment committee, presided as toastmaster.

All of the speakers emphasized their appreciation of this innovation of a purely social evening with ladies present as of greatest benefit in extending acquaintance and promoting fellowship among the local engineers. This affair did not take the place of a regular monthly technical meeting, but was an added event in the year's calendar of the section. So successful was the dinner (nearly two hundred attended) that another is already being talked of for the fall, and a smoker is planned to occur before the summer recess.

INFORMAL SOCIAL DINNER OF THE NEW YORK SECTION OF THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS, MACHINERY CLUB, MAR. 29, 1916

ENGINEERING AFFAIRS

The Canadian Association of Stationary Engineers has secured the use of the Montreal Technical School for its convention in that city July 26-29.

Engineering Coöperation—An invitation has been issued by the Committee on Engineering Coöperation to all engineering organizations to send delegates to a conference, to be held Apr. 13 and 14 in the rooms of the Western Society of Engineers, Monadnock Block, Chicago. The following items among others may be considered:

1. Coöperation among engineering organizations. Is it desirable? In what way is it practicable?
2. Benefits of coöperation in securing greater efficiency in the larger matters of concern to the individual engineer, to the profession and to the public.
3. Methods of coöperation now in practice in various localities; results attained in Philadelphia, St. Louis, St. Paul and others places.
4. Various kinds of engineering societies and committees and the relative efficiency of their operations.
5. Relation of the specialized or exclusive national engineering societies to their local sections or branches and to the more inclusive local engineering society or club.
6. Result of coöperation in securing wider diffusion of knowledge on engineering subjects, as illustrated at Cleveland and elsewhere.
7. The engineering profession as a whole in its present condition as regards public esteem.
8. Reasons for decline in attendance at engineering colleges. Is it indicative of healthful conditions or of proper methods of education?
9. Employment; methods and results as practiced by various engineering societies; an exchange of ideas.
10. Legislative activity, proper limits to be set, dangers to be avoided and needs of more systematic and better-directed efforts.

It is desired that a representative body of engineers attend this meeting and be prepared to take part in the discussion. If it is impossible to send delegates, it is hoped that as many as possible will give the matter of procedure and organization careful thought and give the committee the benefit through written discussion. The Committee on Engineering Coöperation is composed of F. H. Newell, chairman, University of Illinois, Urbana, Ill.; C. E. Drayer, secretary, Cleveland, Ohio (secretary, Cleveland Engineering Society); Willard Beahan, Cleveland, Ohio (past president, Cleveland Engineering Society); H. H. Esselstyn, Detroit, Mich. (past-president, Detroit Engineering Society); Farley Gannett, Harrisburg, Penn. (past-president, Engineers Society of Pennsylvania); Charles R. Gow, West Roxbury, Mass. (civil engineer and contractor); George H. Herrold, St. Paul, Minn. (president, Civil Engineers Society of St. Paul); A. J. Himes, Cleveland, Ohio (past-president, Cleveland Engineering Society); John C. Hoyt, Washington, D. C. (president, Washington Engineering Society); A. Stucki, Pittsburgh, Penn. (past-president, Engineers Society of Western Pennsylvania); D. Robert Yarnall, Philadelphia, Penn. (vice-president, Engineers Club of Philadelphia); John Younger, Buffalo, N. Y. (president, Engineers Society of Buffalo)—all volunteer members who seek to bring about cooperation through existing organizations. When a society is found capable and willing to carry on the work of this committee, its self-imposed duties will be lightly transferred and the existence of the committee will have been justified.—"Engineering News."

PERSONALS

Carroll E. Adams has resigned his position with Jenks & Ballou to become engineer of the Glenlyon Dye Works, Saylesville, R. I.

John McK. Ballou, formerly with the Babcock & Wilcox Co., Bayonne, N. J., is now with the Ford Marine Appliance Co., New York.

E. A. Averill has left the Standard Stoker Co. to take the position of vice-president of the newly organized Locomotive Feed Water Heater Co.

Curtis A. Mees, designing engineer of the Southern Power Co., Charlotte, N. C., has resigned, effective May 1, to open an office as a consulting engineer in that city.

Robert G. Nye has resigned as factory manager of the Buffalo Forge Co. to take a similar position with the Alberger Pump and Condenser Co. at its Newburgh works.

William Tietze, formely chief engineer of power at the Pierce, Fla., plant of the American Agricultural Chemical Co., has been appointed chief engineer of the Cudahy Brothers Co., Cudahy, Wis.

Frank R. Wheeler, for the past ten years associated with the C. H. Wheeler Manufacturing Co. on the Pacific Coast and in Chicago, has returned to Chicago as district manager of the Middle Western territory, with office at 1322 Marquette Building.

Daniel W. Mead, formerly professor of hydraulic and sanitary engineering at the University of Wisconsin, is now associated with F. W. Scheidenhelm in the practice of consulting engineering, with offices in the Equitable Building, New York.

Arthur L. Westcott has been appointed superintendent of buildings at the University of Missouri and will have charge of the university's lighting, heating and plumbing equipment.

He was formerly assistant professor of mechanical engineering in the university.

Thomas R. H. Murphy, of the firm of Joseph H. Wallace & Co., New York, has resigned to become resident engineer of the Mettagami Pulp and Paper Co. in charge of building its hydro-electric development and sulphite pulp mill at Smooth Rock Falls, Ont., Canada.

George M. Basford, who was chief engineer of the railroad department of Joseph T. Ryerson & Son, is now president of the recently organized Locomotive Feed Water Heater Co., New York. This company will develop and handle for locomotive use the film heater designed and patented by Luther D. Lovekin, of the New York Shipbuilding Co.

BOOKS RECEIVED

INDUSTRIAL LEADERSHIP. By H. L. Gantt. Published by Yale University Press, New Haven, Conn. Cloth; 5x7½ in.; 128 pages; 9 charts. Price, $1.

COAL AND COKE. By Frederick H. Wagner. Published by McGraw-Hill Book Co., Inc., New York. Cloth; 6x9 in.; 431 pages; 137 illustrations; charts; tables. Price, $4.

THE "MECHANICAL WORLD" ELECTRICAL POCKET BOOK FOR 1916. Published by the Norman, Remington Co., Baltimore, Md. Cloth; 4x6¼ in.; 298 pages; 130 illustrations; tables. Price, 25c.

NEW PUBLICATIONS

NEW PUBLICATIONS OF THE BUREAU OF MINES

Bulletin 86. "Some Engineering Problems of the Panama Canal in Their Relation to Geology and Topography." By Donald F. MacDonald.

Bulletin 89. "Economic Methods of Utilizing Western Lignites." By E. J. Babcock. 1915. 74 pp., 5 pl., 5 fig.

Bulletin 114. The Manufacture of Gasoline and Benzene-Toluene from Petroleum and Other Hydrocarbons," 1915. 268 pp., 9 pl., 45 fig.

Technical Paper 93. "Graphic Studies of Ultimate Analyses of Coals." By Oliver C. Ralston, with a preface by Horace C. Porter. 1915. 41 pp., 3 pl., 6 fig.

Technical Paper 129. "Metal-Mine Accidents in the United States During the Calendar Year 1914." Compiled by Albert H. Fay.

Miners' Circular 20. "How a Miner Can Avoid Some Dangerous Diseases." By A. J. Lanza and Joseph H. White.

A limited supply of these publications is available for free distribution. Publications should be ordered by number and title. Applications should be addressed to the Director of the Bureau of Mines, Washington, D. C.

DESIGN OF INTAKES, SCROLL CASES AND TURBINE DRAFT TUBES FOR SINGLE RUNNER TURBINES. By A. G. Hillberg, hydraulic engineer, Park Row Building, New York City. A collection of reprints from the "Engineering Record," prepared for free distribution by the author.

This series of four articles reprinted from the "Engineering Record" of Oct. 2, Oct. 9, Nov. 13 and Nov. 20, 1915, is of special interest and no inconsiderable value and importance to any contemplating the installation of hydraulic turbine waterwheels.

The first and second articles, on "Design of Scroll Cases and Intakes for Single-Runner Turbines Analyzed," are in two parts. Part 1 deals with the efficiency of waterwheels depending upon the water passages as well as upon the wheels themselves, and the necessity of steady flow and absence of eddies for the highest efficiency. Part 2 takes up the location of case, allowances to be made in calculations, and discusses the desirable shape of cross-sections and the floor and roof.

The other two articles are on the subject, "Design of Turbine Draft Tubes Analyzed." Part 1 covers the assumptions that have to be made, new formula derived for reducing velocity of the water leaving the turbine and the shape and size of the tube, while Part 2 deals with the theory and formulas developed in part 1 and applied to a typical problem embodying practical conditions.

While the subjects are treated with a good deal of mathematics, as they must of necessity be to deal with the theory of the formula developed, the conclusions can be accepted without the necessity of tracing through the mathematics, and with the illustrations shown it is possible to provide for installations of waterwheels with properly shaped casings and water passages to develop good efficiency.

Those interested in the scientific phases of the subject will appreciate the inclusion of the mathematical development of the formulas for the curves.

ENGINEERING AS A CAREER. A series of papers by eminent engineers. Edited by Prof. F. H. Newell and C. E. Drayer. Published by D. Van Nostrand Co., New York. Size, 5x7½ in.; 214 pages. Price, $1.

Most of the articles constituting this book first appeared in the Cleveland "Plain Dealer" and the "Scientific American" and were prepared as a help to young men at the point of choosing a profession, or their parents, teachers, or friends who are helping them to choose. The several writers attempt to show the opportunities in the particular branch of engineering that each is in and the qualifications necessary to be successful in those fields.

Perhaps the best idea of the nature of the book can be had from a list of the chapters or papers and their authors: "The Engineer and His Profession," by A. J. Himes; "Shall My Boy Become an Engineer," by Franklin De R. Furman; "Mechanical Engineering," by Worcester R. Warner; "Railway Engineering," by A. W. Johnston; "Hydraulic Engineering," by Chester W. Larner; "Metallurgical Engineering," by J. H. Herron; "Electrical Engineering," by W. H. Abbott; "Chemical Engineering," by M. C. Whitaker; "Iron and Steel Making," by S. T. Wellman; "Marine Engineering," by J. C. Workman; "Sanitary Engineering," by R. Winthrop Pratt; "Municipal Engineering," by Robert Hoffman; "Municipal Needs," by Rudolph Blankenberg; "Bridge Engineering," by Frank C. Osborn; "Architecture," by Benjamin S. Hubbell; "Mining," by F. B. Richards; "Opportunities for a Mining Engineer," by Henry S. Munroe; "The Lure of Private Practice," by Ernest McCullough; "Vocational Guidance," by James F. Barker; "Scientific Manufacturing and Its Opportunities," by Waldemar Kaempffert; "Incomes of Technically Trained Men," by David Edgar Rice; and "Technical Man in Business," by John Ritchie, Jr.

Each a contribution by an expert, it is natural that such a collection of articles should far exceed in value to the reader a book by any single author. The variety of treatment also adds to the appeal. The articles, while not of as great import to those who have passed the point of selecting their life work, are equally interesting and might help those not so far on the wrong track to get restarted in a more suitable line of endeavor.

CORRELATION OF THE MECHANICAL AND MAGNETIC PROPERTIES OF STEEL

A review of the work done in correlating the magnetic and mechanical properties of steel has just been published by the Bureau of Standards, Department of Commerce, in its Scientific Paper No. 272. Special attention is paid to the commercial application of the magnetic data as criteria of the mechanical fitness of a given steel and of magnetic changes of steel under stress as indications of the state of strain. The evidence presented shows that the interrelation of the magnetic characteristics and the mechanical behavior of steel is so close that the magnetic examination in conjunction with the mechanical tests may be expected to add considerably to our knowledge of the material.

The magnetic method tests the whole amount of material and not merely some surface phenomenon. It does not destroy the test piece, but leaves it unaltered. Thus it is possible to apply a magnetic test to the identical material that is to enter into a given structure.

Copies of the publication, the title of which is "Correlation of the Mechanical and Magnetic Properties of Steel," will be sent free upon request to the Bureau of Standards, Washington, D. C.

BUSINESS ITEMS

Owing to the growth of its New England business, the Open Coil Heater & Purifier Co., of Indianapolis, Ind., has recently moved into larger quarters at 97 Haverhill St., Boston, Mass., and is now located with F. W. Foster & Sons Co., who have been appointed local agents for the "Stickle Steam Necessities." Chas. J. Guenther, New England manager, has general supervision of the agents in New England.

The General Specialty Co., 295 Michigan St., Buffalo, N. Y., has recently made sales of Demon Tube cleaners to Berghoff Brewing Association, Fort Wayne, Ind. City of Cleveland, Cleveland, Ohio. Forsyth Electric Light & Power Co., Forsyth, Mont. Sears, Roebuck & Co., Chicago, Ill. A. M. Byers Co., Pittsburgh, Penn. American Hominy Co., Indianapolis, Ind. and of Torpedo Scale Removers to Hyde Park Brewery, St. Louis, Mo. Sanborn Electric Co., Sanborn, Iowa. Western Coal & Mining Co., Bush, Ill. Northern Michigan Transit Co., Chicago, Ill. Southern Coal, Coke & Mining Co., Belleville, Ill. Westfield Electric Light Plant, Westfield, N. Y.

Classified Ads

POSITIONS OPEN

Canada

TWO MECHANICAL ENGINEERING DRAFTSMEN wanted; should have from six to eight years' experience designing. Apply by letter, stating qualifications and salary expected. The Canadian Copper Co., Copper Cliff, Ont.

Indiana

MECHANICAL ENGINEER, capable of designing small steam turbines; detail ability, experience, salary, etc. P759—Power, Chicago.

Pennsylvania

SEVERAL FIRST-CLASS DRAFTSMEN wanted at once, of general mill and blast furnace experience; state age, experience, present salary and salary wanted in first letter; also when available; central location, Pittsburgh. P687—Power.

SEVERAL DRAFTSMEN wanted at once, experienced in power plant and general piping work; state age, experience, present salary and salary wanted in first letter; also when available; central location, Pittsburgh. P688—Power.

Employment Agencies

CORRESPONDENT

THE UNDERSIGNED plans and conducts correspondence for positions in technical, manufacturing and professional lines; $2500 to $15,000 men exclusively; complete privacy assured; no commission charged—only service fee and postage. Send name and address only, in confidence, for prefatory details. R. W. Bixby (established 1910), P1 Niagara Square, Buffalo, N. Y.

POSITIONS WANTED

Canada

CHIEF OPERATING ENGINEER open for engagement in United States or Canada; can take charge of big plant; experienced with pumping station and high-tension power units, reciprocating or turbine (Curtis) and all auxiliaries, water-tube boilers, stokers, economizers, etc.; good executive; practical mechanic on repairs and renewals; age 42; married; strictly temperate; A1 references. PW762—Power.

Illinois

CHANGE desired; 10 years' experience in charge of large steam turbo-power plant installation, operation and efficiency investigation; technical education; Mem. A. S. M. E. PW760—Power, Chicago.

New York

POWER-PLANT OPERATING ENGINEER or assistant; licensed man; experienced in the care and operation of engines, boilers and auxiliary equipment; immediately available; location immaterial. PW678—Power.

OPEN FOR ENGAGEMENT as mechanical superintendent, master mechanic, salesman or representative; mechanical engineer, 38 years old, qualified in executive matters; 12 years' experience with management of steam, gas, oil and electrical installations connected with power, mining and milling work; long residence in Latin-American countries; fluent Spanish. Address "Mechanical," PW758—Power.

Virginia

BOILER SUPERINTENDENT and combustion engineer open for position; can handle any size or kind; prefer South or Western location. PW763—Power.

Civil-Service Opportunities

NEW YORK STATE CIVIL SERVICE—Open competitive examination for junior electrical engineer, Public Service Commission for the First District, $901.-$1200. per annum will be held throughout the State on May 6, 1916. Minimum age twenty-one years. At least three years' electric railroad, electric lighting or electrical or mechanical installation experience required. Open to non-residents. A number of temporary appointments pending the examination will be made. For further details, communicate with Public Service Commission for the First District, 154 Nassau Street, New York City.

WANTED

MANUFACTURER wants either patented or patentable ideas on boiler and engine room specialties; cash or royalty basis. W676—Power.

AGENTS AND SALESMEN

REPRESENTATIVES for a new type of a thoroughly established and successful steam specialty; state experience and territory covered. W629—Power, Chicago.

IF YOU ARE a manufacturers' agent, handling a limited line and want to add some boiler room equipment—not specialties—in Chicago territory, write. W757—Power.

YOUNG TECHNICAL GRADUATE to sell power-plant specialties; good opportunity for advancement; state age, education, experience and salary desired. W761—Power.

AGENTS handling engine and boiler room specialties, in every section, for side line, paying large commissions. Give experience, lines carried and territory covered. W390—Power.

WELL-VERSED boiler-room and combustion men or established engineering agencies to sell mechanical stokers on a liberal commission basis; we manufacture three distinct types to meet all requirements; natural and forced draft. W749—Power, Chicago.

A LIVE POWER-PLANT SPECIALTY SALESMAN who can qualify will have an opportunity to join the sales force of a well-known manufacturer on a commission proposition, offering extraordinary returns. Send details to W732—Power, Chicago.

MISCELLANEOUS

PATENT ATTORNEYS

PATENTS. C. L. Parker, patent attorney, formerly member Examining Corps, U. S. Patent Office, McGill Bldg., Washington, D. C. Inventor's handbook sent upon request.

IS YOUR INVENTION VALUABLE? Ask A. P. Connor, electrical, mechanical engineer (ex-chief electrical engineer for New York). Patent attorney. Lawyer. Carroll St., S. E., Washington, D. C.

ENGINEERS—Do you want to utilize your exhaust steam for heating or drying purposes without back pressure on your engine? If so address Monash Engineering Co., 1417 West Jackson Blvd., Chicago, Ill.

For Sale

Second Hand Equipment

Rates: Less than 4 insertions 75 cents per line—4 to 11 insertions 70 cents per line—12 or more insertions 65 cents per line

Equipment Wanted items appear at the end of this list.

ADVERTISERS' NAMES are abbreviated in most of these items. Complete names and addresses are as follows:

POWER Mchy. Exchange, 14 Morris St., Jersey City, N. J.

BOILERS

1—54"x12' Erie horiz. return tubular, butt strapped, 125 lb. —L. F. Seyferts Sons, Inc., 437 N. 3d St., Phila., Pa.

1 80-hp. horizontal, new flues.—New York Metallic Bedstead Co., 184 Pacific Ave., Jersey City, N. J.

125 H.P. H.R.T. boiler, butt strap, triple riveted, 125 lb. pressure, $375.—POWER MCHY.

ENGINES, GAS

Westinghouse vertical, 40 hp., now running; in best possible condition. Selling because of purchase of a larger unit. Delivery immediately.—The Acklin Stamping Co., Toledo, O.

1—17x24 Climax horizontal with 48"x18" pulley, 60 HP., 4 cycle.—E. F. Sturtevant Co., Hyde Park, Boston, Mass.

Two 25 K.W. Westinghouse 230 volt generators direct connected Westinghouse gas engines, $800 each; 12½ K.W. Crocker Wheeler 125 volt generator direct connected Nash vertical gasolene engine and switchboard, $475.—POWER MCHY.

ENGINES, STEAM

Allis Corliss 18x36 with rolling mill type bed; belt flywheel 12'x30"; first class condition.—P. O. Box 1537, Phila., Pa.

American Ball engine, 160 hp., 16"x14", 250 r.p.m. with belt wheel 72"x15", new, was never set on foundation. FS753—POWER.

300 H.P. Corliss, in operation only six months, excellent condition. Immediate delivery. Full particulars on inquiry.—Militaire Motor Vehicle Co., Buffalo, N. Y.

14x30 Burlingame corliss, practically new, $475; 16x38 Rollins corliss, perfect condition, $500.—POWER MCHY.

GENERATING UNITS

Engine and Generator—One Hamilton Corliss 18x36x42" horizontal cross compound engine with 14x16" cast iron flywheel; direct connected to Westinghouse 580-kw. generator, 440 v., 761 amp., 3-phase, 25-cycle, 107 r.p.m. Generator is revolving field; the Exciter is steam driven. No Switchboard with this outfit. Engine now running condensing. All of the equipment, such as pumps and piping, is in connection with the Engine. The condenser is of the surface type. 140 lb. steam pressure used. Floor space 21 ft. 8 inches wide—28 ft. long over all. Equipment has been in operation five years and can be seen in operation at our Cedar Rapids Mill. For price and full information address National Oats Co., St. Louis, Mo.

1 Ridgway engine, 14x14, 124 hp., and 1 Ridgway dynamo, 75 kw., 250 volts; both practically new and form a unit.—The Ford Lumber & Mfg. Co., Winchester, Ky.

Two 1040 H. P. horizontal cross compound, heavy duty, mill type Buckeye engines 24"x42x36, 120 R. P. M. each direct connected to 500 K. W., 250 volt, Westinghouse Type "Q" generators. Excellent condition, good as new. Now in operation. If interested, write for full information and prices.—Box 197, Elyria, Ohio.

50 K.W. 230 volt generator direct connected Duplex engine, American Ball make, $700; 60 K.W. 125 volt generator direct connected Ideal engine, $500; 34 K. W. Crocker Wheeler 125 volt generator direct connected Skinner engine, $550.—POWER MCHY.

WANTED

2—250-hp. water-tube boilers for not less than 150 lb. steam pressure; must be able to stand casualty inspection. State price.—Chambersburg Ice & Cold Storage Co., Chambersburg, Penn.